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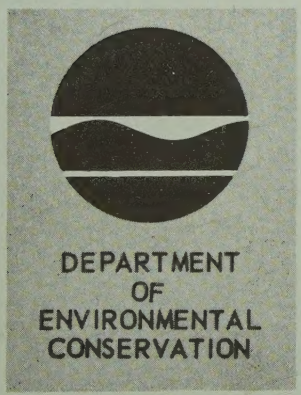

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PUBLIC ATTITUDES TOWARD BLACK BEARS IN THE CATSKILLS[1]

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ABSTRACT

To provide information for managing the black bear population in the Catskill region, a questionnaire survey was conducted of the attitudes of private landowners, camp managers and corporate landowners toward bears. Few of the respondents reported having had problems from bears, very few believed bears to be a nuisance or a menace, and most wanted bears perpetuated in the Catskills and were willing to tolerate some nuisance from them. The majority of private landowners and a plurality of both camp managers and corporations wanted the bear population to increase. Experience with bears was associated with positive attitudes toward the species among all three groups.

Black bears (*Ursus americanus*) have been an important part of the history and ecology of the Catskill region of New York. Among the State's three black bear populations, the one inhabiting the range in this region is intermediate in size compared with those occupying the Adirondack and Allegany ranges (Figure 1). The Catskill range has been defined as an area of some 3,300 square kilometers (McCaffrey et al., 1976) and is characterized largely by the Catskill Mountain landform (Stout, 1958). Bear habitat is provided by continuous forest, on the publicly-owned Forest Preserve as well as private lands, that extends to the New York-Pennsylvania boundary.

During the 20 years prior to 1970 there was a marked decline in the number of bears annually taken by hunters in the Catskills. Concern about

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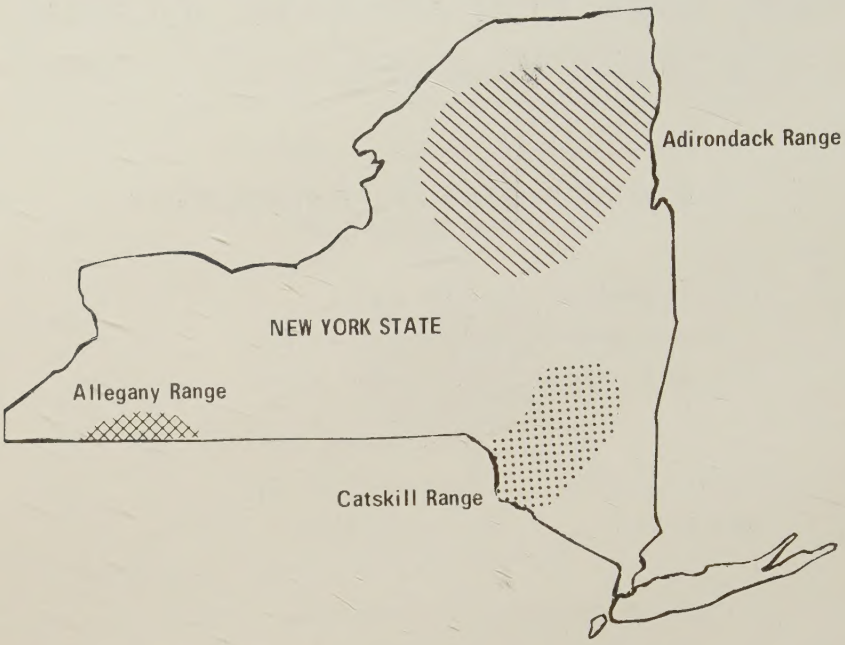

Figure 1. Location of the three primary ranges of the black bear in New York.

the implications of this decline prompted the Department of Environmental Conservation to undertake, beginning in 1970, an intensive research program to determine the status of the bear population there, its ecology and inter-relationships with the human population. Preliminary findings presented by McCaffrey et al. (1976) indicated that: (1) two sub-populations are present; (2) harvests by hunting are a major limiting factor; and (3) land-use patterns dictate hunting pressure as well as human activities that directly affect the maintenance of bear habitat. Continued analyses of data on the sex and age of bears taken have confirmed the existence of two sub-populations (O'Pezio, 1975). The northern component occupies the larger range area (about 2,250 square kilometers) that is dominated by the Catskill Forest Preserve. The southern component occupies a range area of about 1,050 square kilometers that lies largely south of Route 17 and consists chiefly of private lands. The two areas are indicated in Figure 2.

Since 1975, radio telemetry has been used to obtain information on the habitat preferences, home ranges, reproductive success and natural mortality of bears in this region. A primary objective of this phase of the research is the re-definition of the bear habitat. Knowledge of the available habitat and the compatibility of the population with human land use and other public interests is important in the development of a long-range bear management plan to perpetuate the resource, provide for its

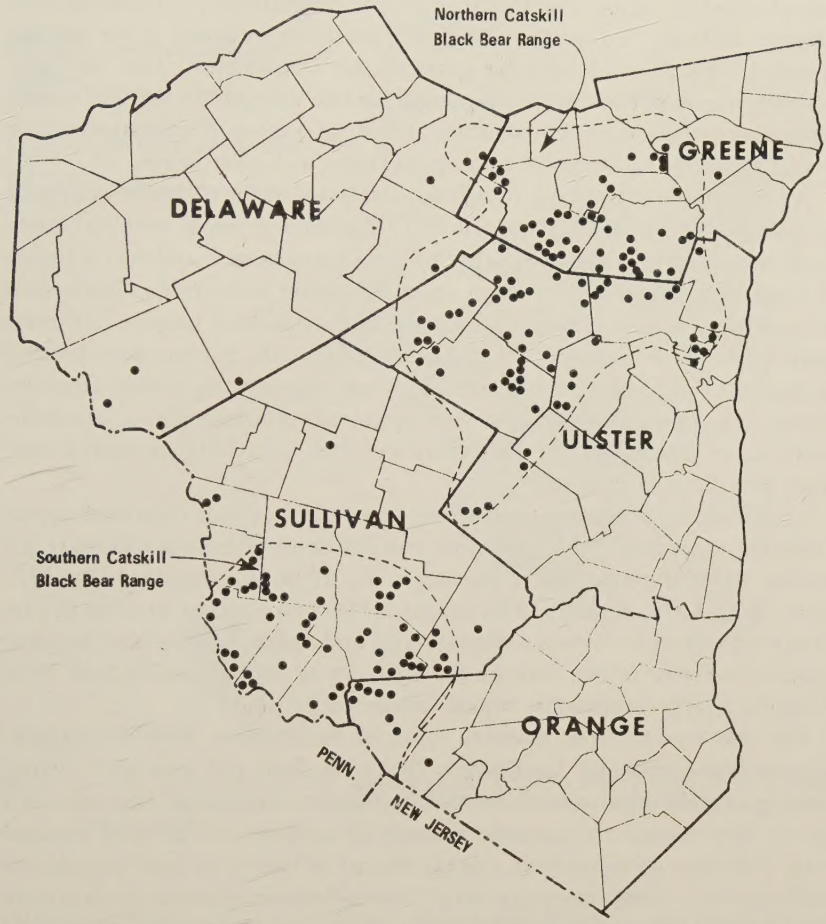

Figure 2. Map of study area showing range areas occupied by the northern and southern components of the bear population as evidenced by the distribution (black dots) of bears killed by hunters from 1970 to 1973 (after McCaffrey et al., 1976).

maximum beneficial use and maintain populations at levels compatible with the public interest. Also, since 1970, data have been collected concerning property damage and other conflicts between bears and humans as well as public attitudes toward bears. Findings show that, during the period 1970-1975 when a low but stable population of about 300 bears inhabited the Catskill region, hunter use and hunting values of bears were high, while conflicts with humans were relatively low.

In 1976, an experimental program of population increase was undertaken (O'Pezio and Clarke, 1976). The strategy called for a graduated return to population levels comparable to those that occurred prior to 1970. Following each increment of growth, a period of population stability

was planned to permit assessment of public compatibility with the greater number of bears. To achieve the first population increase, it was recommended, and implemented by order of the Department, that the bear hunting season in the Catskills be closed for two years, 1976 and 1977. As a result the population nearly doubled. Hunting seasons in subsequent years would be designed to stabilize the population at higher levels.

A pilot survey of public attitudes toward bears in the Catskills was made in the summer of 1976 (O'Pezio, 1977). The work involved personal interviews with recreationists at selected public campgrounds and access points in the Forest Preserve. The data collected, while indicating considerable unawareness of the presence of bears, also evidenced positive attitudes toward the bear resource. A broader, systematic survey was deemed necessary to provide an adequate data base representing public attitudes before the population increase was perceived. Accordingly, a questionnaire survey (Brown et al., 1979) was undertaken in 1977 through a contract with Cornell University.

In developing the survey, it became apparent that little information was available regarding public attitudes toward bears. Previous studies (e.g.: Bacon, 1974; Baptiste, 1977; Baptiste et al., 1979; Burghardt et al., 1972; Cole, 1974, 1976; Rowell, 1976; Stokes, 1970) had concentrated on the attitudes of visitors in various national parks and the management of bears at specific locations rather than on the attitudes of people owning land in or living in a large geographic region inhabited by bears.

For this study, three primary types of landowners were recognized: private (noncorporate) landowners (both resident and absentee), camp managers and corporations[2]. Private landowners were chosen because as a group they control the greatest amount of nonpublic lands and because their collective opinions have a great deal of influence on bear population management. Camp managers were chosen because their enterprises have considerable potential to be affected by bears, and corporations because of the vast tracts (i.e., bear habitat) they control. Information sought included general attitudes toward black bears, nuisance or damage incidents involving bears, sightings of bears and tolerance of bears.

METHODS AND PROCEDURES

The study area was divided into four strata by separating the ranges of the northern and southern sub-populations into "occupied" and "unoccupied" parts, i.e., northern occupied range, northern unoccupied range, southern occupied range and southern unoccupied range. To facilitate the method chosen for drawing the questionnaire sample, political boundaries were used (Figure 3). These strata included all or parts of Albany,

[2]"Corporation" was used as a general term for all businesses and organizations included in the sample, whether actually incorporated or not.

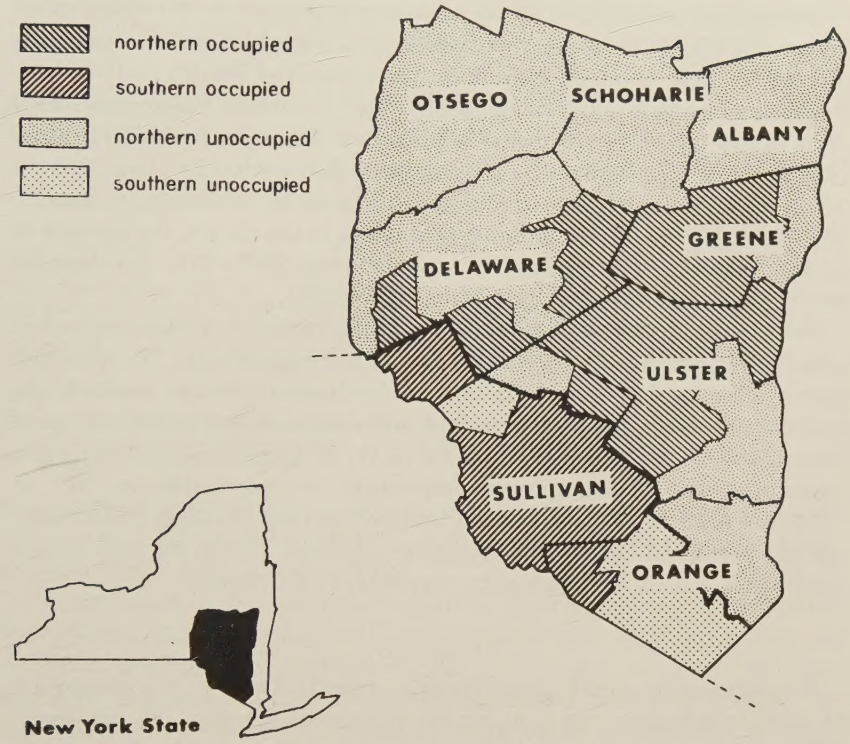

Figure 3. The study area used for assessing public attitudes toward bears in the Catskill region showing its division by political boundaries into range strata for purposes of sampling.

Delaware, Greene, Orange, Otsego, Schoharie, Sullivan and Ulster Counties and encompassed 138 towns in the Catskill region. Private landowners were designated as residents or absentees according to whether or not they lived in these rural towns.

The term "unoccupied" does not mean that this range is devoid of bears. Rather, the terms "occupied" and "unoccupied" were devised for convenience in making this survey. For both sub-populations, there is range where the presence of bears has been common knowledge for generations, and there is other range where bears are more scarce and their presence is not so well known. Both constitute bear habitat, and comparison of the attitudes of landowners in the two situations was an important element of the survey. However, because political boundaries were used and include territory that is not bear habitat, the terms do not represent ecological demarcations of primary and secondary range, although they do in general separate bear habitat with respect to population density. Nevertheless, the terms are artificial and should not be compared literally.

Names and addresses of camp managers (managers or directors) of all 394 active (in 1977) recreational-vehicle and organizational camps in the study area were obtained from State Department of Health mailing lists. Samples of private landowners (2,323) and corporate landowners (647) were drawn systematically from the tax rolls of the towns in the study area. The samples approximated a geographical distribution by town, and an effort was made to obtain equal numbers of resident and absentee owners. But because of the differing number of towns in the ranges, the samples of private landowners in the four strata varied from 528 to 692, and those for the corporate landowners varied from 136 to 204.

During the spring of 1978, each group was mailed a questionnaire and cover letter, plus up to three follow-ups to nonrespondents. The questionnaires[3] developed for the three types of landowners covered basically the same topics and included background, informational and attitudinal questions many of which were identical for all three. Questions concerning past experience with bears requested information on observations in 1977, in 1976 and prior to 1976. Data were analyzed by range stratum (where sample size permitted) and by the aggregate response. The 95 per cent level of confidence was used to designate "significant" differences.

FINDINGS

Response to the questionnaire is summarized in Table 1. The proportion of useable responses was greatest for private landowners (72 per cent), followed by camp managers[4] (65 per cent) and corporate landowners (52 per cent).

CHARACTERISTICS OF THE LANDOWNER GROUPS

Four out of five residents lived in rural areas. The majority of both resident and absentee landowners responding from each range were male. Both groups had a mean age of 53, and there was little variation between ranges or between residents and absentees within ranges. The chief occupational categories for the resident landowners were retired and white-collar (28 per cent each), while among the absentee landowners white-collar workers (42 per cent) outnumbered any other group. Ten per cent of the resident landowners were farmers.

The majority of camp managers (59 per cent) represented organizational camps rather than recreational-vehicle campgrounds. Most managers of recreational-vehicle campgrounds (91 per cent) served people

[3]Copies of the questionnaire are available from the senior author upon request.

[4]Due to the small number of campgrounds in the southern unoccupied range and the low response from that range, a telephone follow-up of nonrespondents was made, and seven complied. Except for the few specific questions asked on that follow-up, data for that stratum are not reported in the text separately, but they are included in the aggregate statistics.

TABLE 1. RESPONSE OF LANDOWNERS IN THE CATSKILLS TO QUESTIONNAIRE CONCERNING THEIR ATTITUDES TOWARD BLACK BEARS

Type of landowner	Number mailed	Number non-deliverable	Adjusted sample	Useable responses	
				Number	Per cent
Private landowner					
Resident	1,160	58	1,102	805	73
Absentee	1,163	104	1,059	744	70
Total	2,323	162	2,161	1,549*	72
Camp manager	394	28	366	237§	65
Corporate landowner	647	62	585	305	52

*Six of these did not furnish useable information with respect to Tables 2 and 3. However, they, and an additional three for which the range category was unknown because the code numbers used to relate the questionnaires to range were obliterated, yielded information on certain other questions.

§A telephone follow-up of 12 nonresponding camp managers in the southern occupied range yielded an additional seven responses for a few selected questions.

of all ages, whereas organizational camps primarily served youngsters 10 to 15 years old. About 12 per cent of the managers had had campers report seeing a bear at their camp in 1977.

For corporate landowners, the majority of the respondents (55 per cent) were owners of the corporation chosen for the sample. Most others were in positions described as "executive officer" (19 per cent) or "general manager" (12 per cent). The corporations surveyed had owned land in the Catskills for an average of 25 years and employed an average of 41 people. Most of those that reported bear sightings on their land (71 per cent) were situated in predominately forested areas.

BEAR HUNTING

Among the private landowners a significantly greater proportion of residents than absentees (46 vs. 34 per cent) were hunters. Most of these hunters pursued big game and about three out of five big game hunters would shoot a bear if given the opportunity. About one-third of the camp managers were hunters. For these groups as a whole in each range, majority opinion was split regarding the necessity of hunting to insure a bear population compatible with human land use and available bear habitat.

A plurality (43 to 48 per cent) of the corporate representatives from all but the southern unoccupied range believed that hunting is necessary to keep bear numbers compatible with human land use and available bear habitat. In the southern unoccupied range, a plurality (44 per cent) said they didn't know. For the four strata, 16 to 25 per cent of the respondents believed hunting is not necessary.

CONTACT WITH BEARS

Bear sightings reported by the respondents are summarized in Tables 2

TABLE 2. INCIDENCE OF BEAR SIGHTINGS REPORTED BY PRIVATE LANDOWNERS IN THE CATSKILLS, ACCORDING TO RANGE AND RESIDENCE STATUS

Range and Residence status	Observations regionwide			Observations on own property		
	Number of respondents†	Respondents reporting sightings		Number of respondents†	Respondents reporting sightings	
		Number	Per cent		Number	Per cent
Northern occupied*						
Resident	188	92	48.9	187	30	16.0
Absentee	199	62	31.2	199	19	9.5
Northern unoccupied*§						
Resident	248	65	26.2	248	23	9.3
Absentee	234	34	14.5	233	7	3.0
Southern occupied*						
Resident	193	122	63.2	189	50	26.5
Absentee	167	61	36.5	166	29	17.5
Southern unoccupied*						
Resident	171	45	26.3	170	16	9.4
Absentee	143	30	21.0	143	14	9.8
Total						
Resident	800	324	40.5	794	199	15.0
Absentee	743	187	25.2	741	69	9.3

†A few respondents who reported having seen a bear in the Catskills did not indicate whether or not the sighting was on their own property. These are included for regionwide observations but omitted for those on respondent's own property.

*Difference between residents and absentees in proportion of respondents who had seen bears was significant according to chi-square test ($P > 0.95$).

§Difference between residents and absentees in proportion of respondents who had seen bears on their own property was significant according to chi-square test ($P > 0.95$).

TABLE 3. INCIDENCE OF BEAR SIGHTINGS BY RESPONDING PRIVATE LANDOWNERS IN THE CATSKILLS OVER THE YEARS PRIOR TO 1978, ACCORDING TO RANGE AND RESIDENCE STATUS

Range and residence status	Number of respondents	Incidence of sightings: Percentage who saw bears			Number of sightings†			
					1977		1976	
		In 1977	In 1976	Prior to 1976	Total††	Mean	Total††	Mean
Northern occupied								
Resident	188	7.4	5.9	45.2	17 (185)	0.092	16 (187)	0.086
Absentee	199	4.5	2.5	27.6*	7 (197)	0.036	5 (199)	0.025
Northern unoccupied								
Resident	248	4.4	6.0	21.8	15 (247)	0.061	21 (246)	0.085
Absentee	234	3.0	4.7	12.0*	14 (234)	0.060	14 (234)	0.060
Southern occupied								
Resident§	193	19.7	19.2	57.5	55 (185)	0.297	82 (193)	0.425
Absentee	167	8.4*	8.4*	32.3*	24 (165)	0.146§§	30 (166)	0.181§§
Southern unoccupied								
Resident	171	7.6	5.3	22.2	16 (170)	0.094	15 (171)	0.088
Absentee	143	7.0	4.2	18.2	9 (141)	0.064	7 (143)	0.049
Total								
Resident	800	9.5	9.0	36.0	103 (787)	0.131	134 (797)	0.168
Absentee	743	5.4*	4.8*	21.9*	54 (737)	0.073§§	56 (742)	0.076§§

†Number of sightings differs from percentage of respondents who had seen bears because some respondents reported more than one sighting while others gave no number.

††Figures in parentheses represent number of respondents who gave useable data for number of sightings and which was used in calculating means.

*Difference between residents and absentees was significant according to chi-square test ($P > 0.95$).

§Difference between 1977 and 1976 in mean number of sightings was significant according to t-test ($P > 0.95$).

§§Difference between residents and absentees was significant according to t-test ($P > 0.95$).

Table 4. Incidence of Bear Problems Experienced By Responding Private Landowners in the Catskills, According to Range and Residence Status

Range and residence status	Respondents			Number of problems									
		Reporting problem		Year of occurrence§			Type of problem						
	Total number*	Number	Per cent	1977	1976	Prior to 1976	Frightened person	Annoyance	Beehive damage	Car damage	Livestock damage	Property damage	Orchard damage
Northern occupied													
Resident	187	7	3.7	1	0	6	1	1	3	1	1	..	..
Absentee	198	1	0.5	0	0	1	..	..	1	..	..	..	..
Northern unoccupied													
Resident	247	2	0.8	0	0	2	..	..	..	..	1	1	..
Absentee	232	3	1.3	0	0	1	..	..	..	1	..	..	..
Southern occupied													
Resident	195	6	3.1	1	0	8	1	3	2	..	2	..	1
Absentee	166	2	1.2	1	1	0	..	3	..	..	..	..	..
Southern unoccupied													
Resident	171	3	1.8	2	0	1	1	1	..	..	..	1	..
Absentee	139	1	0.7	0	0	0	..	1	..	..	..	..	..
Total													
Resident	800	18	2.3	4	0	17	3	5	5	1	4	2	1
Absentee	735	7	1.0	1	1	2	..	4	1	1	..	..	..

*Totals are less than those in Table 1, and also differ from those in Tables 2 and 3, because of failure of some respondents to answer certain questions.

§One absentee respondent in southern occupied range and one in southern unoccupied range who reported annoyance problems failed to give dates.

and 3. For private landowners, sightings were more common on the occupied than on the unoccupied ranges and among residents than absentees on all ranges. About one-third of those who had seen a bear reported sighting one on their own property.

Only 2 per cent of the responding resident landowners and 1 per cent of the absentees had experienced problems from bears at any time in the past (Table 4). In total, only 27 problems were reported, of which five occurred in 1977, one in 1976 and 19 sometime prior to 1976 (dates were not given for the other two). The majority (20) occurred in the occupied ranges, while 21 were reported by resident landowners. In 12 instances the bear was merely an annoyance (nine) or frightened someone (three), while 15 represented property damage (six to beehives). No case of human injury was reported. Only four of these problems had been reported to the State Department of Environmental Conservation, and two respondents were satisfied with the Department's assistance.

The total monetary loss due to bear problems, reported by 14 respondents, was $1,485. Of this, $420 was incurred in 1977, $20 in 1976, and $1,045 prior to 1976. These losses ranged from $5 to $350 and averaged $106 per respondent who had suffered damage. For both 1976 and 1977 all the losses reported were from the occupied range, while for the

TABLE 5. CAMP MANAGERS WHO REPORTED PERSONALLY HAVING SEEN BEARS IN THE CATSKILLS, ACCORDING TO YEAR AND RANGE

Range	1977		1976		Prior to 1976		Total†		Total respondents††
	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent	
Total sightings									
Northern									
Occupied	8	12.5	12	18.8*	15	23.4	26	40.6*	
Unoccupied	4	4.9	3	3.7*	14	17.1	16	19.5*	
Southern									
Occupied	7	8.3	16	19.0*	21	25.0	29	34.5*	
Unoccupied	0	. .	0	. .	1	tr	1	tr	
Total	19	7.9	31	12.8	51	21.1	72	29.8	
Sightings on own property									
Northern									
Occupied	9	14.1*	8	12.5*	12	18.8	19	29.7	64
Unoccupied	2	2.4*	1	1.2*	6	7.3	7	8.5	82
Southern									
Occupied	5	6.0*	12	14.3*	12	14.5§	17	20.2	84
Unoccupied	0	. .	0	. .	1	tr	0	. .	12§§
Total	16	6.6	21	8.7	31	12.8	43	17.8	242

†Total less than sums of yearly values because many respondents reported seeing bears in more than one year.

††All percentages for each range stratum based on total respondents for that stratum.

§This percentage based on sample size of 83 because one respondent failed to answer this part of question.

§§Includes seven responses to telephone follow-ups.

*Difference in proportion of respondents who had seen bears and those who had not was significant according to chi-square test ($P > 0.95$).

period prior to 1976 light damage ($170) was reported from the unoccupied range.

Bear sightings by camp managers were uncommon; most managers (70 per cent) had never seen a bear in the Catskills (Table 5). Sightings were more frequent in the occupied range. A majority of those who had seen a bear also had had sightings on their camp property. Only 2 per cent of the respondents reported having had problems from bears at their camps. These were all annoyance problems; no incidents of human injury or economic loss were reported. The greatest incidence was reported from the southern occupied range where 5 per cent of the camp managers had had problems at some time although none was reported for 1977 in this area. The northern unoccupied range was the only area where a problem was reported for 1977.

The proportion of corporation representatives who reported bear sightings on their property in the occupied ranges (34 and 30 per cent) was twice that for the unoccupied ranges (16 and 14 per cent). Only one damage problem was noted, although about one-quarter of the corporations reported bears on their property.

Attitudes About Bears

The attitudes of the respondents are best presented under different topics pertaining to their knowledge and experience with bears.

Limiting Factors Factors that private landowners believed had the greatest influence on the bear population were food availability and the amount of forested land. Except for resident landowners in the northern occupied range, who believed food and hunting to be the greatest influences, opinions were relatively similar between ranges and between resident and absentee landowners within ranges. For those camp managers and corporate representatives who expressed an opinion, food availability was considered the most important limiting factor. They considered hunting and the amount of forested land as being secondary influences.

Bear Behavior and the Presence of Bears Attitudes about bear behavior were not strongly developed among the respondents. For each group, a plurality of those who expressed an opinion believed that bears are timid and stay away from their property or that bears occasionally approach their property but seldom cause damage. Few thought bears often cause damage or are a menace.

With the exception of absentees on the southern unoccupied range, a plurality of both resident (33 to 52 per cent) and absentee (38 to 41 per cent) landowners in each range wanted to see a bear on their property. However, in each case notable proportions of the residents (14 to 28 per cent) and absentees (20 to 32 per cent) wanted their bear sightings restricted to remote areas of the Catskill Mountains. Few respondents had no interest in seeing a bear in the wild.

The desirability of having campers sight bears varied considerably among the camp managers. While 20 per cent were not interested in having their campers ever see a bear in the wild, many others wanted campers to see a bear occasionally on undeveloped land (26 per cent) or in remote areas (19 per cent). About 13 per cent wanted campers to see a bear occasionally at their camp, and 14 per cent wanted them to see a bear near but not on camp property. Opinion was similar for all three ranges where an adequate response from camp managers was received (i.e., except the southern unoccupied range).

Corporate opinion regarding the degree to which bears should inhabit the Catskill region was quite polarized. For each range, a plurality of respondents (41 to 55 per cent) would not mind occasionally having a bear on their property, but a notable minority (33 to 44 per cent) would like to restrict bears to remote areas of the Catskill Mountains.

TOLERANCE OF NUISANCE ACTIVITY Opinion concerning tolerance of nuisance activity by bears is summarized in Table 6. For private landowners, respondents indicated considerable tolerance of such activity. A plurality of both residents and absentees in each range would accept occasional annoyance, and many would accept annoyance and some degree of economic loss. Only about one out of five respondents (16 to 22 per cent for residents and 15 to 27 per cent for absentees) indicated that no degree of annual nuisance activity by bears would be acceptable. Although these attitudes were relatively consistent across the four ranges, respondents from the northern occupied range were most tolerant of nuisance activity while those from the southern unoccupied range were least tolerant.

Among camp managers, nuisance activity would not be acceptable to 38 per cent, but many others indicated a tolerance for occasional annoyance (36 per cent) or economic loss of under $100 (21 per cent). Very few respondents (6 per cent) would tolerate an economic loss of over $100. Respondents from each range demonstrated this same general attitude, but those from the southern occupied range were the most tolerant of economic loss.

Nuisance activity would be unacceptable to two out of five corporations. Slightly over one-third of the respondents from each range reported that their corporation would tolerate annoyance but not economic loss. Most of the others indicated that some economic loss would be tolerated, although few would accept amounts in excess of $300. This attitude prevailed in each range.

MAINTAINING THE BEAR POPULATION Maintaining a population of bears in the Catskills was important to most private landowners, camp managers and corporations, although majority opinion was split on the emphasis that should be placed on this. Private landowners in the northern occupied range were the extreme in that a plurality of both residents and absentees thought land-use regulations should be employed throughout

the Catskills to protect bear habitat. In the other ranges, a plurality of such landowners believed that maintaining the bear population should be achieved through a balance of human land-use needs and bear habitat requirements.

Table 6. Degree of Annual Nuisance Activity By Bears That Would Be Acceptable to Responding Landowners in the Catskills, According to Range and Residence Status

Range and residence status	Number of respondents	Degree of nuisance activity*				
		None	Annoyance§	Under $100	$100 to $300	Over $300
Private landowners						
Northern occupied						
Resident	176	15.9	40.3	27.8	9.1	6.8
Absentee	190	15.3	46.3	27.9	5.8	4.7
Northern unoccupied						
Resident	234	23.9	44.4	24.4	2.6	4.7
Absentee	225	17.3	43.1	32.0	5.3	2.2
Southern occupied						
Resident	186	19.9	44.1	30.1	4.3	1.6
Absentee	160	25.0	43.1	26.3	4.4	1.3
Southern unoccupied						
Resident	161	26.7	41.0	24.8	3.1	4.3
Absentee	135	27.4	36.3	31.1	3.7	1.5
Total						
Resident	757	21.7	42.6	26.7	4.6	4.4
Absentee	710	20.4	42.8	29.4	4.9	2.5
Camp managers†						
Northern occupied	61	41.1	34.4	18.0	1.6	4.9
Northern unoccupied	77	36.4	42.8	15.6	2.6	2.6
Southern occupied	82	36.6	30.5	26.8	3.7	2.4
Southern unoccupied	5	(2)	(1)	(2)	(0)	(0)
Total	225	37.8	35.6	20.9	2.7	3.1
Corporations†						
Northern occupied	81	40.7	34.6	18.5	3.7	2.5
Northern unoccupied	79	45.6	35.4	15.2	1.3	2.5
Southern occupied	75	41.3	38.7	10.7	4.0	5.3
Southern unoccupied	45	42.2	37.8	6.7	8.9	4.4
Total	282	42.3	36.5	13.8	3.9	3.5

*Figures in percentage of respondents, except those in parentheses for camp managers in southern unoccupied range.

§No dollar value.

†Residence status not applicable.

Nearly a quarter of the camp managers thought that land-use regulations should be employed throughout the Catskills to protect bear habitat. The greatest proportion (36 per cent) believed that maintaining the bear population should be achieved through a balance of human land-use needs and bear habitat requirements. An additional 28 per cent believed that maintaining bears is important, but only to the extent that consideration for bears does not conflict with human land-use needs. Finally, about 12

per cent in each range thought that human land-use needs for bear habitat are more important than bears.

The greatest proportion of corporations in each range (28 to 46 per cent) believed that a balance of human land-use needs and bear habitat requirements should be achieved or that something should be done to maintain a bear population, but 27 to 34 per cent felt that this should be done only to the extent that consideration for bears does not conflict with human land-use needs. About one out of five corporations in each range believed that land-use regulations to protect bear habitat are warranted. Only 11 to 16 per cent considered human land-use needs for bear habitat more important than bears.

FUTURE BEAR POPULATION DESIRED An increase in the Catskill bear population (from their perception of 1976-1977 levels) was desired by the majority of private landowners (both resident and absentee) in the northern occupied, northern unoccupied and southern occupied ranges and by the majority of residents in the southern unoccupied range. Advocacy of increasing the bear population was greatest among residents. Only 20 per cent or less of the landowners (resident or absentee) from any range did not want an increase.

Increasing the population was preferred by a plurality of the camp managers (43 per cent), while 28 per cent did not want an increase and 29 per cent weren't sure. Respondents did not differ greatly between the ranges in their preferences regarding future bear population trends.

A plurality of corporate representatives (42 to 45 per cent) from the northern occupied, northern unoccupied and southern occupied ranges wanted the bear population to increase, but a plurality of those from the southern unoccupied range were noncommittal. Over-all, about 16 to 26 per cent did not want an increase.

INFLUENCE OF EXPERIENCE WITH BEARS ON ATTITUDES

It was evident that the attitude of a respondent was strongly influenced by whether or not he had seen bears or had otherwise had experience with them.

PRIVATE LANDOWNERS The desire of private landowners to have the bear population increase seemed to be associated with their personal sightings of bears and relatively unaffected by their residence status. For both residents and absentees, a significantly greater proportion of those who had seen bears, than of those who had not, wanted the population to increase. This relationship applied to each range. Respondents who had seen a bear also were more likely than others to want to see them on their own property and less likely either to want their observations restricted to remote areas of the Catskills or to never see a bear. This attitude also applied to each range for both residents and absentees. Acceptance of bear nuisance activity was greater among respondents who had seen bears than

among those who had not. Landowners who had seen a bear had a greater tendency to comment on bear behavior than did those who had not, and more of them indicated either that bears are "timid and stay away from people and residences" or that they "occasionally approach residences but seldom cause damage." Generally, both residents and absentees who had seen a bear were less likely than those who had not to believe that doubling the bear population would increase nuisance situations, safety risks and bear-vehicle collisions. This view was consistent in each range.

Having seen a bear on one's property had little effect on the generally positive attitude of private landowners (both resident and absentee) toward increasing the bear population. But a greater proportion of those who had seen a bear on their property, compared with those who had not, wanted to continue seeing them there. People who had seen a bear on their property were more inclined than others to give an opinion regarding bear behavior, and such experience did not cause them to dislike bears. Rather, the greatest proportion of those who offered an opinion believed that bears are timid or that they seldom cause damage. Further, respondents who had seen a bear on their property did not differ significantly from those who had not in their tolerance of bear nuisance activity or in their interest in maintaining a population of bears in the Catskills.

Bear sightings had been experienced by significantly greater proportions of hunters than nonhunters for both resident (54 vs. 30 per cent) and absentee (43 vs. 16 per cent) landowners. Hunters were more willing than nonhunters to comment on bear behavior, with greater proportions of hunters indicating that bears are timid or seldom cause damage. Hunters were also somewhat more tolerant of bear nuisance activity, but losses of $100 or more due to bears were considered acceptable by few landowners regardless of hunting status. The most striking difference between hunters and nonhunters was that more hunters, among both resident (78 vs. 48 per cent) and absentee (81 vs. 42 per cent) landowners, wanted the bear population to increase.

Camp Managers Camp managers who had seen a bear were more willing to express opinions about them than were those who never had seen one. Familiarity with bears was associated with more positive attitudes as evidenced by the greater proportions of such respondents who believed that bears are timid (38 vs. 13 per cent) and seldom cause damage (32 vs. 12 per cent). This general relationship existed in each range. In both occupied ranges, managers familiar with bears also expressed a greater willingness to incur financial loss (38 vs. 21 per cent). Camp managers who had seen bears were more likely to want land-use regulations to protect bear habitat than were others (33 vs. 19 per cent), although a plurality of each group (40 and 35 per cent, respectively) preferred balancing bear habitat requirements and human land-use needs. Camp managers who had seen bears in the Catskills tended to want their campers to see bears on

nearby undeveloped lands, near their camp and at their camp, while most of those who had not seen bears either had no interest in having their campers see bears or wanted sightings restricted to nearby undeveloped lands or remote areas of the Catskills. As with private landowners, a much larger proportion of the camp managers who had seen bears than of those who had not (65 vs. 34 per cent) wanted the bear population to increase. This relationship was consistent in each range. Similarly, more hunting than nonhunting managers (70 vs. 30 per cent) wanted the bear population to increase. This, too, applied to all ranges but was especially striking in the southern occupied range where the ratio was 91 to 26 per cent.

The attitude of camp managers was also influenced by the experience of campers at their facilities.[5] Managers whose campers had seen bears were more inclined than others to want bears occasionally on camp property (26 vs. 12 per cent) or near camp property (39 vs. 12 per cent) and less inclined to want their campers to see bears only in remote areas of the Catskills (4 vs. 22 per cent) or never to see one (0 vs. 29 per cent). However, similar proportions of both groups (30 and 26 per cent, respectively) wanted sightings on nearby undeveloped lands. Campers sightings of bears also seemed to be associated with the tolerance of bear nuisance activity by camp managers. A greater proportion of the managers whose campers had seen bears than of those whose campers had not (88 vs. 60 per cent) would tolerate some annoyance or economic loss due to bears. The most striking difference between these two groups was the proportion (80 vs. 39 per cent) who wanted the bear population to increase.

CORPORATIONS So few corporations reported bear sightings on their property that comparisons could be made only in terms of the aggregate data to give some indication of where major differences in attitude may exist between corporations with and those without a history of bear sightings. Opinions about bear behavior were held most frequently by respondents from corporations having had sightings on their land. Here again such experience was associated with positive attitudes. Generally, the greatest proportion of those who reported no bear sightings indicated that they were not familiar with bears (65 per cent), while most others thought that bears are timid (23 per cent) or seldom cause damage (10 per cent). For corporations on whose lands bears had been seen, the greatest proportion believed that bears seldom cause damage (46 per cent), while 23 per cent believed bears are timid and 28 per cent did not have an opinion. Very few respondents (1 per cent) believed that bears often cause damage or considered them a menace.

Nuisance activity was unacceptable to half of the corporations on whose lands bears had never been sighted. On the other hand, this was true of

[5]This information was requested only for 1977, and range comparisons are not made because only 25 respondents had campers report bear sightings.

only a quarter of those where bears had been reported, while nearly half considered occasional annoyance acceptable and a quarter would tolerate some economic loss. Maintaining the bear population was given more support by corporations that had had bear sightings on their lands than by those that had not. Furthermore, an increasing bear population was desired by 64 vs. 38 per cent of these groups, respectively.

Overview of Respondents Who Had Had Problems With Bears

Of the 25 private landowners who had had problems, 50 per cent wanted the bear population to increase, while 38 per cent did not and 12 per cent were noncommital. Of the same group, 40 per cent wanted to see bears on their property, 28 per cent wanted sightings restricted to remote areas of the Catskills and only 8 per cent never wanted to see a bear. Also, while 24 per cent would not find any level of nuisance activity by bears acceptable, 40 per cent would tolerate occasional nuisances and 36 per cent would tolerate some economic loss. Of the 20 respondents who both reported problems and stated an opinion regarding bears, three-quarters believed that bears are timid or seldom cause damage. Most people who had experienced problems nevertheless believed it important to maintain the bear population in the Catskills.

Although only five managers had experienced bear nuisance problems at their camps, it is worth noting that even these people generally had positive attitudes toward bears. Four of the five were willing to tolerate annoyance from bears, while the other would incur damage of under $100. In addition, four of the five wanted the bear population to increase (the other wasn't sure) and believed that maintaining the population was important enough to warrant land-use regulations throughout the Catskills to protect bear habitat.

DISCUSSION AND IMPLICATIONS

These data indicate that private landowners, camp managers and corporate landowners in the Catskills had, at the time of this survey (1978), a moderate to high degree of tolerance for black bears. But more important, their responses generally revealed an atmosphere of acceptance for a bear population larger than that extant prior to the effort to increase it. This conclusion is supported by (1) the generally positive attitudes regarding bear behavior, for those offering an opinion, (2) the acceptability of at least occasional bear nuisance activity, (3) the varying, but generally positive, responses regarding maintenance of the bear population in the Catskills and (4) the endorsement by the majority of private landowners for an increase in the population.

On the other hand, although many respondents expressed acceptability of annoyance and some economic damage from bears, only a few had ac-

tually experienced problems. How the attitudes of others might be affected by first-hand experience with bear nuisance situations cannot be predicted. Some of those who had had damage gave estimates of $100 or more. Means of alleviating occasional financial losses might be useful in maintaining the acceptability of bears.

Two findings imply that considerable potential exists for increasing public acceptance of black bears in this region. First, a plurality of respondents had no opinion concerning bear behavior, suggesting that it would be helpful for the Department to continue, if not increase, its public education efforts regarding bears. The opportunity to influence favorably these people without an opinion seems encouraging for the bear management program. Second, more favorable attitudes about the black bear prevailed among those respondents who had personally seen a bear, which may indicate that increased contact would further enhance acceptability.

All the foregoing points should be considered in the light of one reality, i.e., since few respondents had actually seen a bear in the Catskills, and even fewer had had any problems from them, a doubling of the bear population may have little impact in the currently defined occupied ranges. A population change in the unoccupied or peripheral ranges might be more noticeable.

Unlike earlier studies that were site-specific and aimed primarily at resolving recreationist-bear conflicts, this study has afforded a broader perspective on the attitudes held by landowners in an area encompassing an entire bear population. These landowners represent an important segment of the public by virtue of their having continuous potential for interaction with bears and, therefore, a vested interest in bear population densities. The study has provided base-line information on public attitudes against which to compare changes that may be associated with further increases in the abundance of bears. This is considered essential for evaluating the experimental program of population increase in the Catskill region. The relative compatibility between the public and various levels of the bear population is a vital consideration with respect to long-range management of the bear resource.

LITERATURE CITED

BACON, E. S. 1974. Use of a survey of park visitor attitudes and knowledge to help formulate education programs. In: 2nd Eastern Workshop on Black Bear Management and Research, Great Smoky Mountains National Park (M. R. Pelton and R. H. Conley, Ed.):207-213. (Contribution of Tenn. Fed. Aid in Fish and Wildl. Rest. Project W-46-R)

BAPTISTE, M. E. 1977. A survey of visitor knowledge, attitude, and judgment concerning black bears at Shenandoah National Park. M. S. thesis, Virginia Poly. Inst. and State Univ. Library, Blacksburg.

BAPTISTE, M. E., J. B. WHELAN AND R. B. FRARY. 1979. Visitor perception of black bear problems at Shenandoah National Park. Wildl. Soc. Bull. 7(1):25-29.

BROWN, T. L., D. J. DECKER AND D. L. HUSTIN. 1979. Public Attitudes toward black bear in the Catskills. Outdoor Rec. Res. Unit, Dept. Nat. Resources, Cornell Univ., Ithaca.

Burghardt, G. M., R. O. Heilala and M. R. Pelton. 1972. Knowledge and attitudes concerning black bear by users of the Great Smoky Mountains National Park. In: Bears – Their Biology and Management (S. Herrero, Ed.):255-273. IUCN Publ. New Ser. 23, Int. Union Cons. Nature and Nat. Resources, Morges, Switzerland.

Cole, G. F. 1974. Management involving grizzly bears and humans in Yellowstone National Park, 1970-73. BioScience 24:335-338.

_____ 1976. Management involving grizzly and black bears in Yellowstone National Park, 1970-1975. U.S. Dept. Int., Natl. Park Serv., Nat. Resource Rept. 9.

McCaffrey, E. R., G. B. Will and A. S. Bergstrom. 1976. Preliminary management implications for black bears, *Ursus americanus*, in the Catskill region of New York State as a result of an ecological study. In: Bears – Their Biology and Management (H. R. Pelton, J.W. Lentfer and G. E. Folk, Jr., Ed.):235-245. IUCN Publ. New Ser. 40, Int. Union Cons. Nature and Nat. Resources, Morges, Switzerland.

O'Pezio, J. 1975. Status of the black bear populations in the northern and southern Catskill ranges. New York Federal Aid in Fish and Wildlife Restoration Project W-89-R-19 (separate report for Job X-1) N.Y.S. Dept. Environ. Cons. (mimeo.)

_____ 1977. Public attitudes toward black bears in the Catskills. New York Federal Aid in Fish and Wildlife Restoration Project W-89-R-21 (performance report for Job X-8). N.Y.S. Dept. Environ. Cons. (mimeo.)

O'Pezio, J., and S. H. Clarke. 1976. Recommendations for the Catskill bear hunting season: 1976-1978. New York Federal Aid in Fish and Wildlife Restoration Project W-89-R-20 (separate report for Job X-6). N.Y.S. Dept. Environ. Cons. (mimeo.)

Rowell, G. 1976. How Yosemite is solving the bear problem. Natl. Wildl. 14(3):24-28.

Stokes, A. W. 1970. An ethologist's view on managing grizzly bears. BioScience 20:1154-1157.

Stout, N. J. 1958. Atlas of Forestry in New York. Bull. 41, State Univ. Coll. Forestry at Syracuse Univ., Syracuse.

ICHTHYOPLANKTON OF THE LOWER HUDSON ESTUARY, NEW YORK[1]

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ABSTRACT

Effective management of many anadromous fish must be based on a coastwise perspective of the ecosystems involved and knowledge of the faunal characteristics of the important estuaries used by these species. Data concerning the early developmental stages of 49 species of ichthyoplankton from the Lower Hudson estuary have provided a basis for comparing the abundance and distribution of this fauna in two different estuarine systems: the Hudson River and the Patuxent River (a tributary of Chesapeake Bay). The dominant fish species in the brackish waters of both estuaries was the bay anchovy (*Anchoa mitchilli*). The seasonal movements of fish larvae are generally predictable in relation to the cyclic movements of the salt front.

It is becoming increasingly apparent from research studies that effective management for many important anadromous fish (e.g., striped bass and Atlantic sturgeon) in waters along the Atlantic Coast is dependent on suitable coordination of programs in the different governmental jurisdictions involved. Fisheries management agencies must develop a "coastwise" perspective before anadromous fisheries resources can be realistically appreciated and managed. Accordingly, documentations of the faunal characteristics of individual estuaries are needed as a basis for evaluating the total estuarine-continental shelf complex.

Data on the basic patterns of abundance and of spacial and temporal distribution of the ichthyoplankton of an estuary are an essential element of such documentation. An investigation of the ichthyoplankton organisms present in the Lower Hudson estuary in New York was conducted from March to December in 1972. Special effort was made to determine the movements of fish larvae as influenced by the cyclic movements of the salt front. The findings are presented here and compared with the results of a similar investigation in the Patuxent estuary, a tributary of Chesapeake Bay in Maryland. Although the latter study covered the years 1963, 1964 and 1965, only data for 1963 are used for comparison because sampling effort in that year most closely resembled the effort exerted in the Hudson River.

STUDY AREA

The investigation covered a river area of approximately 129 kilometers

[1]The information presented here was developed through the joint efforts of Boyce Thompson Institute and The Rockefeller Foundation (Grant No. 71023). The author acknowledges the contributions of Jean Dovel in processing the ichthyoplankton samples and the assistance of William Becker in the electronic processing of raw data.

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between New York Harbor and Poughkeepsie (Figure 1) and bracketed the transitional zone between fresh water and salt water at all times. During the study, the interface between fresh water and salt water (salt front) moved from Station 4 (Mt. St. Vincent) in early spring upriver to Station 17 (Newburgh bridge) in the fall. In 1972, maximum salinity at Station 1 was 28.1 ppt in September, and water temperatures at this station ranged from 2.2° C. in November to 27.1° C. in July.

Tofflemire and Hetling (1969) reported that the section of the Hudson River from Irvington north to Saugerties (about 130 kilometers) appeared relatively unpolluted. However, during the present study the area sampled was being subjected to the introduction of appreciable quantities of petroleum products, in the form of ballast and bilge water from vessels using the waterway, as observed on the surface of the water. Also, seven electric-generating power plants were located on the river between Manhattan and Albany, and others are contemplated including the Storm King pump-storage facility proposed for construction adjacent to the U.S. Military Academy at West Point (New York Power Pool, 1974).

METHODS

Sampling in both the Hudson and Patuxent ecosystems was performed in areas characterized by an estuarine salinity gradient. Effort extended across the salt water-fresh water interface into fresh water. In this manner attention could be focused on the transition zone between fresh and brackish water and the interaction between organisms of marine and/or fresh water origin.

Field Procedures

Field collections of ichthyoplankton in the Hudson River were made at 20 stations (Figure 1) on a weekly basis from April 4 to August 16 in 1972. From August 29 to November 29, samples were collected at 2-week intervals. Sampling was done from an open boat, but after November inclement weather precluded such operations. The sampling methods were similar to those used in the Patuxent River in 1963 as described by Dovel (1971).

Conventional plankton nets with 200 μ and 500 μ straining aperatures and 57- and 113-centimeter mouth diameters, respectively, (Dovel, 1964; Anonymous, 1968) were fitted with runners and towed at approximately 1.5 to 2.5 knots along an eight-step oblique path from surface to bottom. The nets were towed for 1 minute at each step (level), assuring equal sampling effort at each water level although, unfortunately, vertical contamination could not be avoided. Net clogging was not a problem. Each net was equipped with a General oceanic digital flow meter for measuring the approximate volume of water strained. Salinity was determined with a

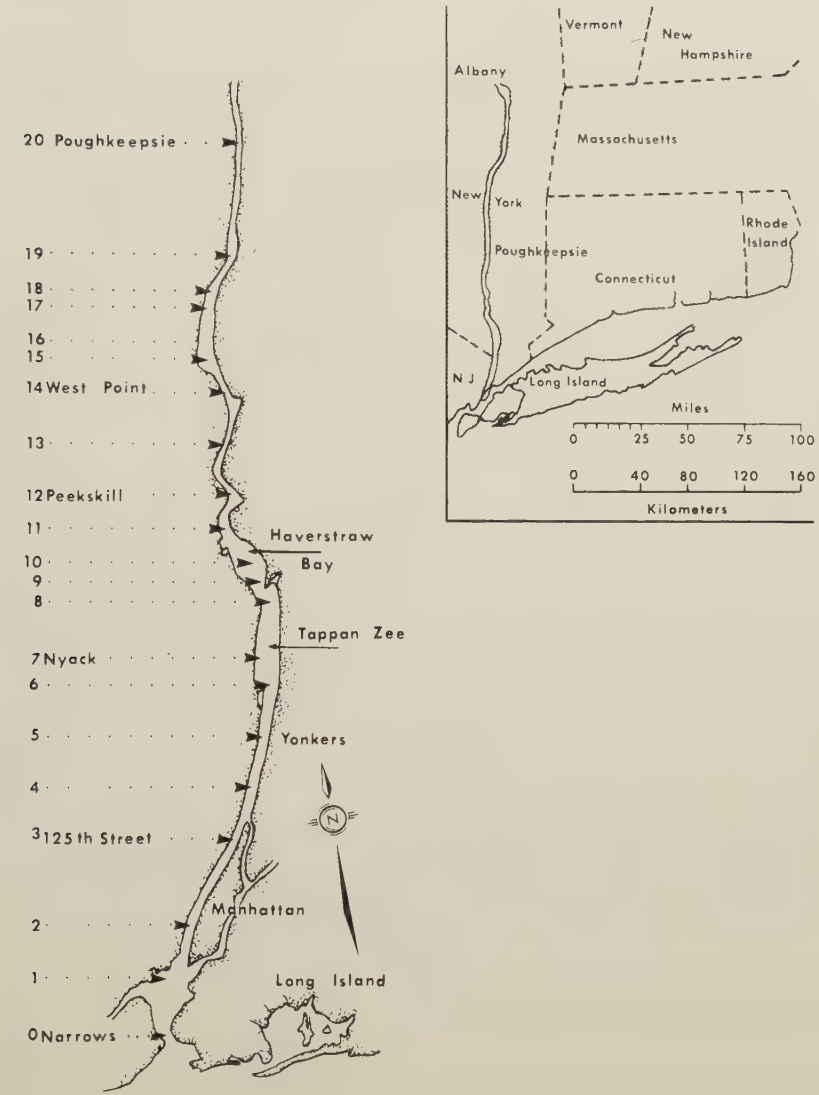


Figure 1. Extent of study area on Hudson River and location of ichthyoplankton sampling stations, 1972-1975.

Beckman RS-5 salinometer at intervals of 1.5 miles along the vertical water column.

At the termination of each tow, the nets were thoroughly washed from the outside, and the specimens collected were placed in 10 per cent formalin.

Laboratory Procedures

Specimens were washed with tap water and emptied into shallow black containers. Tap water was added to a total depth of about 6 millimeters. Large field collections were split into eight aliquots using a modification of the whirling vessel technique described by Wilborg (1951) and Kott (1953). The numbers of organisms were determined for one aliquot and multiplied by eight to represent the whole sample. The resultant values were rounded to the nearest 100 for those of 1,000 or more and to the nearest 10 for those from 100 to 999, while those less than 100 were used as calculated.

Data for the Hudson and Patuxent areas were computer processed concurrently to explore basic patterns of organism distribution, abundance and movement as correlated with station location, season, water temperature and salinity.

Results and Discussion

During the work on the Hudson River in 1972, over 2.8 million fish eggs, larvae and juveniles representing 49 species of fish were collected. During the period 1960-1971, the author collected over 5.1 million fish eggs and larvae from the Chesapeake system, most of which came from an intensive study of the Patuxent estuary in 1963 (Dovel, 1971). In both cases, the patterns of relative abundance and spatial distribution of estuarine fish, with respect to the salinity gradient, were very similar.

Larvae and Eggs

Larvae of 16 species were common to both areas (Table 1). In each case, five species, including the bay anchovy, striped bass and white perch, accounted for over 98 per cent of the specimens collected. However, the most abundant larvae found in the Patuxent estuary, those of the naked goby, as well as the skilletfish and the striped blenny, were not found in the Hudson and probably did not occur there because these species normally deposit their eggs in hinged shells of the American oyster – shell boxes that were not present in the Hudson River at that time. In addition, several of the species recorded are marine forms which should be more common to the Hudson River sampling area than to the Patuxent because of its proximity to the Atlantic Ocean.

Eggs of the bay anchovy were dominant in the collections from both the Hudson and Patuxent Rivers (Table 2). Sampling was done in or very close to major spawning locations for the anchovy in both systems because viable eggs in early stages of development were found. The greater abundance of hogchoker eggs in the Patuxent may be attributed to the fact that the hogchoker lives in close association with the river bottom, and bottom conditions were probably more suitable there than in the Hudson.

Although eggs of the striped bass, white perch and herring were present

in samples from both systems, their numbers do not indicate the magnitude of spawning for two reasons. First, the areas sampled did not encompass a major portion of the known spawning grounds for any of these species. Second, the eggs of the white perch, and to some degree the herring, are demersal and adhesive, precluding their occurrence in samples taken from the pelagic community. Only those eggs that moved downstream into the areas sampled were collected.

Eggs of the striped bass, white perch, blueback herring and alewife were not found below Stony Point (Station 11) in the Hudson River, but striped bass eggs were collected as far south as this station on May 30. Spawning areas for this species are reputed to include the first 40 kilometers of fresh water upstream from salt water (Rathjen and Miller, 1957; Tresselt, 1952; Massmann et al., 1952; Talbot, 1966); however, in the Hudson River the area may be somewhat larger. In 1973, eggs were collected from 90 to 153 kilometers and from 37 to 164 kilometers above salt water during the weeks of May 28 and June 11, respectively (Texas Instruments, 1973). Spawning in the Hudson River was reported as far north as Coxsackie (river mile 125 or 201 kilometers) by Carlson and McCann (1969) and Texas Instruments (1973) as well as slightly to the south (river mile 100 or 185 kilometers) by Rathjen and Miller (1957).

A few eggs of the Atlantic menhaden were present in both the Hudson and Patuxent Rivers. However, neither represents a major spawning area for this species.

Species Diversity, Abundance and Distribution

Figure 2 shows the total number of ichthyoplankton organisms collected at all sampling stations in the Hudson River between New York Harbor (Station 1) and Poughkeepsie (Station 20) during 1972. Species diversity, as numbers of species, is shown for the same area. Except for Station 1, abundance tended to increase progressively downstream. There are several possible explanations for this.

First, hydraulic forces at the mouth of the river could have been responsible for organism movement and concentration. Second, the majority of ichthyoplankton organisms found just inside the mouth of the river were anchovy eggs which occur over a large area of high-salinity waters in the Lower Hudson and Long Island Sound. Third, it does not appear that this pattern of abundance could be attributed to sampling error because the catch per unit of effort at Station 1 indicated a substantially lower number of organisms present there than at stations upstream. Fourth, the lower abundance in New York Harbor (Station 1) may be attributed to unequal densities of organisms in the four sources of water which merge in the harbor, i.e., the Atlantic Ocean, Long Island Sound, the Hudson River and Newark Bay. Apparently, densities of organisms in the waters of the Lower Hudson exceeded the mean density in the combined waters of New York

Table 1. Catch of Fish Larvae During Sampling in the Lowfr Hudson River (1972) and the Patuxent River (1963)

Species*	Number		Per cent		Catch per 100 cubic meters	
	Hudson	Patuxent	Hudson	Patuxent	Hudson	Patuxent
Naked goby (*Gobiosoma bosci*)	0	375,400	. .	65.82	. .	27,900
Bay anchovy (*Anchoa mitchilli*)	168,600	170,300	70.02	29.86	23,700	16,400
Blueback herring (*Alosa aestivalis*)	32,100	760	13.33	0.13	3,000	88
Alewife (*Alosa pseudoharengus*)						
White perch (*Morone americana*)	16,900	9,400	7.02	1.65	740	110
Atlantic tomcod (*Microgadus tomcod*)	16,100	0	6.69	. .	1,200	. .
Striped bass (*Morone saxatilis*)	4,000	3,700	1.66	0.65	140	800
Atlantic silverside (*Menidia menidia*)	6	2,800	§§	0.49	1	95
Hogchoker (*Trinectes maculatus*)	330	1,800	0.14	0.32	88	200
Atlantic menhaden (*Brevoortia tyrannus*)	28	1,800	0.01	0.32	13	120
Winter flounder (*Pseudopleuronectes americanus*)	1,000	1,600	0.42	0.28	190	50
Yellow perch (*Perca flavescens*)	25	1,400	0.01	0.25	2	190
Striped blenny (*Chasmodes bosquianus*)	0	580	. .	0.10	. .	18
Rainbow smelt (*Osmerus mordax*)	470	0	0.20	. .	110	. .
Northern pipefish (*Syngnathus fuscus*)	360	320	0.15	0.06	26	5
American shad (*Alosa sapidissima*)	270	0	0.11	. .	20	. .
Tessellated darter (*Etheostoma olmstedi*)	190	0	0.09	. .	15	. .
American eel (*Anguilla rostrata*)	130	54	0.05	0.01	6	3
Conger eel (*Conger oceanicus*)	1	0	§§	. .	††	. .
Harvestfish (*Peprilus alepidotus*)	0	91	. .	0.02	. .	6
Carp (*Cyprinus carpio*)	83	0	0.03	. .	5	. .
Longhorn sculpin (*Myoxocephalus octodecemspinosus*)	73	0	0.03	. .	11	. .
Rough silverside (*Membras martinica*)	0	71	. .	0.01	. .	7
Tidewater silverside (*Menidia beryllina*)	§	49	. .	0.01	. .	4
Weakfish (*Cynoscion regalis*)	17	41	0.01	0.01	3	3
Skilletfish (*Gobiesox strumosus*)	0	41	. .	0.01	. .	1
Northern puffer (*Sphoeroides maculatus*)	0	34	. .	0.01	. .	0.2
Atlantic croaker (*Micropogon undulatus*)	0	31	. .	0.01	. .	2
Spottail shiner (*Notropis hudsonius*)	2	30	§§	0.01	††	1
Atlantic herring (*Clupea harengus harengus*)	30	4	0.01	§§	4	0.5
Fourspine stickleback (*Apeltes quadracus*)	0	21	. .	§§	. .	††
Windowpane (*Scophthalmus aquosus*)	21	0	0.01	. .	3	. .
Fourbeard rockling (*Enchelyopus cimbrius*)	12	0	§§	. .	2	. .
Summer flounder (*Paralichthys dentatus*)	9	0	§§	. .	2	. .

Oyster toadfish (*Opsanus tau*)	0	9	. .	§§	. .	0.5
Atlantic cod (*Gadus morhau*)	4	0	§§	. .	1	. .
Bluegill (*Lepomis macrochirus*)	4	§	§§	. .	2	. .
American goosefish (*Lophius americanus*)	4	0	§§	. .	1	. .
Butterfish (*Peprilus triacanthus*)	4	0	§§	. .	2	. .
Banded killifish (*Fundulus diaphanus*)	§	4	. .	§§	. .	1
Silvery minnow (*Hybognathus nuchalis*)	0	4	. .	§§	. .	0.5
Atlantic needlefish (*Strongylura marina*)	0	4	. .	§§	. .	0.2
Tautog (*Tautoga onitis*)	3	0	§§	. .	††	. .
Lined seahorse (*Hippocampus erectus*)	1	3	§§	§§	1	0.2
Spot (*Leiostomus xanthurus*)	§	3	. .	§§	. .	0.2
Seaboard goby (*Gobiosoma ginsburgi*)	†	2	. .	§§	. .	0.2
Golden shiner (*Notemigonus crysoleucas*)	§	2	. .	§§	. .	0.5
Red drum (*Sciaenops ocellata*)	0	1	. .	§§	. .	0.2
Brown bullhead (*Ictalurua nebulosus*)	1	0	§§	. .	1	. .
Yellowtail (*Limanda ferruginea*)	1	0	§§	. .	1	. .
Bluefish (*Pomatomus saltatrix*)	1	0	§§	. .	1	. .
Cunner (*Tautogolabrus adspersus*)	1	0	§§	. .	1	. .
Silver perch (*Bairdella chrysura*)	§	§	. .	. .	. .	. .
Total number of species	35	33	xxx	xxx	xxx	xxx

*Nomenclature after Bailey et al. (1970).
§Known to be present in system but not collected in ichthyoplankton gear.
†Recorded by M. Tabery, Texas Instruments, Inc. (personal communication); specimens collected on waters of 3-15 ppt salinity.
§§Less than 0.01 per cent.
††Less than 0.1 per 100 cubic meters.

TABLE 2. FISH EGGS COLLECTED FROM THE HUDSON AND PATUXENT RIVERS

Species	Hudson (1972)		Patuxent (1963)	
	Number	Per cent	Number	Per cent
Bay anchovy	2,579,800	99.77	1,848,800	88.72
Hogchoker	4,600	0.18	232,900	11.18
Striped bass	770	0.03	2,000	0.10
Herring*	340	0.01	12	§
American shad	240	0.01	. .	. .
Atlantic menhaden	35	§	110	§
White perch	4	§	120	§
Total	2,585,789	100.00	2,083,942	100.00

**Alosa* spp. (non-shad).

§Less than 0.01 per cent.

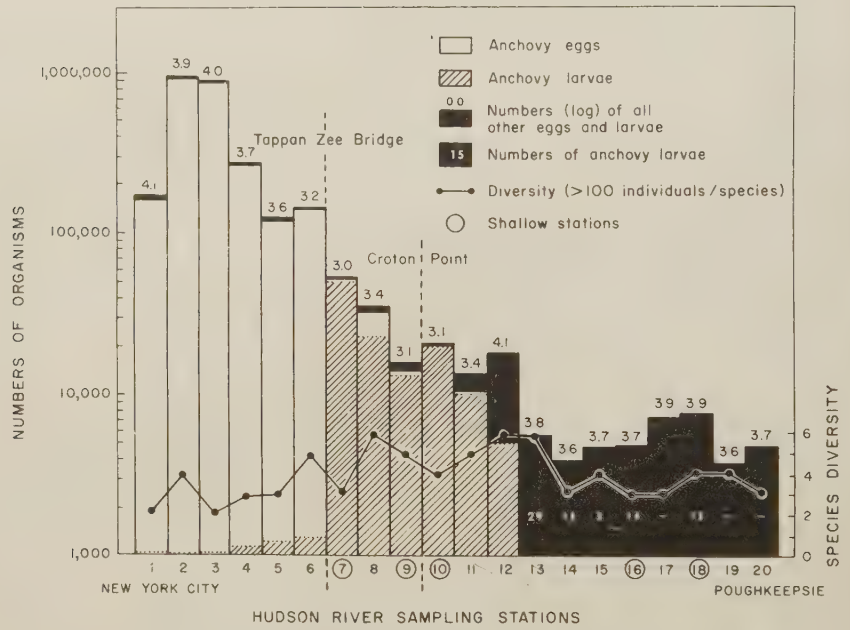


Figure 2. Total numbers of fish eggs and larvae collected in the Hudson River between Stations 1 and 20 from March 27 to October 11 in 1972.

Harbor. The magnitude of the fauna in New York Harbor should thus be evaluated as a sum of the contributions of the individual water masses rather than as a characteristic of the Hudson River.

The progressive decline in number of specimens from Stations 2 and 3 to Station 14 does not necessarily imply either a variation in reproduction (spawning success) or a southerly migration of larval stages. In fact, migration or movement of larval anchovies takes place in the opposite direction, i.e., upstream, as discussed later. The decline in numbers of fish collected per unit of effort can apparently be attributed to a combination of factors

including natural mortality, migration, the greater number of marine species present toward the mouth of the estuary, the overwhelming abundance of the eggs and larvae of the bay anchovy in the Lower Hudson, and a staggered sequence in the occurrence of newly hatched individuals which, after hatching, quickly moved out of upstream areas and accumulated downstream in saline water.

DOMINANT ESTUARINE SPECIES

The dominant species in the ichthyoplankton collections in the Hudson River estuary in 1972 were the bay anchovy, striped bass, white perch, blueback herring and alewife.

BAY ANCHOVY (*ANCHOA MITCHILLI*) This species represented 94.6 per cent of all the ichthyoplankton organisms collected. Eggs, a large proportion of which were dead, were abundant at downstream Stations 1 to 6 (Figure 2) where the salt content of the water ranged from 28.1 to 4.6 ppt. The greatest number was found off 125th Street in Manhattan. Larvae, on the other hand, were abundant from Stations 7 to 12 where water salinity never exceeded 9.2 ppt.

The basic pattern of larval distribution observed in the Hudson was identical to that reported by Dovel (1971) for several Chesapeake areas. For larvae caught in the Hudson River in 1972, a density of 23,600 per 100 cubic meters was recorded on August 1 at Station 7 where water salinity was 4.2 ppt. For Chesapeake Bay during the period 1960-1971, a density of 16,400 per 100 cubic meters was observed on August 5 at a station in the upper Patuxent River where water salinity was 6.0 ppt. Peak densities of anchovy larvae occurred in the Hudson at the time of maximum water temperature and in the Patuxent a week after maximum water temperature. Thus, maximum densities occurred in both systems during similar conditions of temperature and salinity.

Figure 3 illustrates the basic movements of anchovy larvae as interpreted from the sampling data recorded in the present study. When estuarine waters begin to warm in the spring, juvenile and possibly some adult anchovies move upstream into fresh water to feed (A). By late spring mature fish move downstream to spawn (B). Spawning apparently takes place in estuarine waters having a temperature of at least 12° C. and a salinity of generally over 10 ppt. Newly hatched larvae move upstream to low-salinity areas, i.e., less than 10 ppt, to feed (C). The distribution of anchovy eggs and larvae collected and its relationship to salinity are also shown in Figures 4 and 5.

During the summer of 1972, high densities of larvae were found in shallow areas of Haverstraw Bay and the Tappan Zee where populations of zooplankton and phytoplankton were abundant. These waters contained the greatest concentration of larval anchovies observed and apparently constituted the important, low-salinity nursery area of the Hudson River

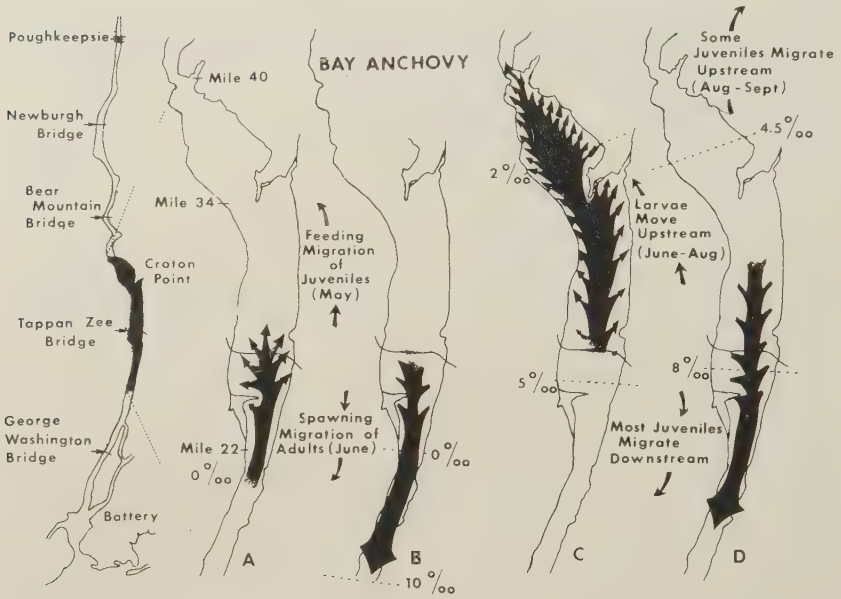


Figure 3. Basic seasonal movements of the bay anchovy in the Hudson River.

A Spring feeding migration of juveniles and possibly adults into freshwater parts of the Tappan Zee and Haverstraw Bay as water temperatures approach 10 ° C.

B Mature fish move into saline waters (more than about 10.0 ppt) to spawn as water temperatures approach 15 ° C.

C Larvae move upstream to low salinity waters rich in zooplankton where they remain.

D Larger juveniles move farther upstream into fresh water, while most of the 0 age group remain in saline waters. The larger juveniles turn and move downstream into saline waters as water temperatures drop below about 10 ° C. with the onset of winter.

for this species. The lower densities noted at Station 1 probably resulted from an upstream movement of larvae and a merging of larvae-poor waters from adjacent areas. The upstream movement of larvae which can be interpreted from Figures 4 and 5 could be due to a response to available food or to the transport of planktonic larvae by the northward penetration of salt water as the summer season becomes progressively drier and the input of fresh water decreases.

In early fall, larval and juvenile anchovies began to move from the low-salinity nursery. The majority of the smaller fish moved south into saltier water, but some larger juveniles were still moving upstream into fresh water as shown in Figures 3 (D) and 5 and Table 3. The fish that moved farthest upstream may have turned and moved downstream before the

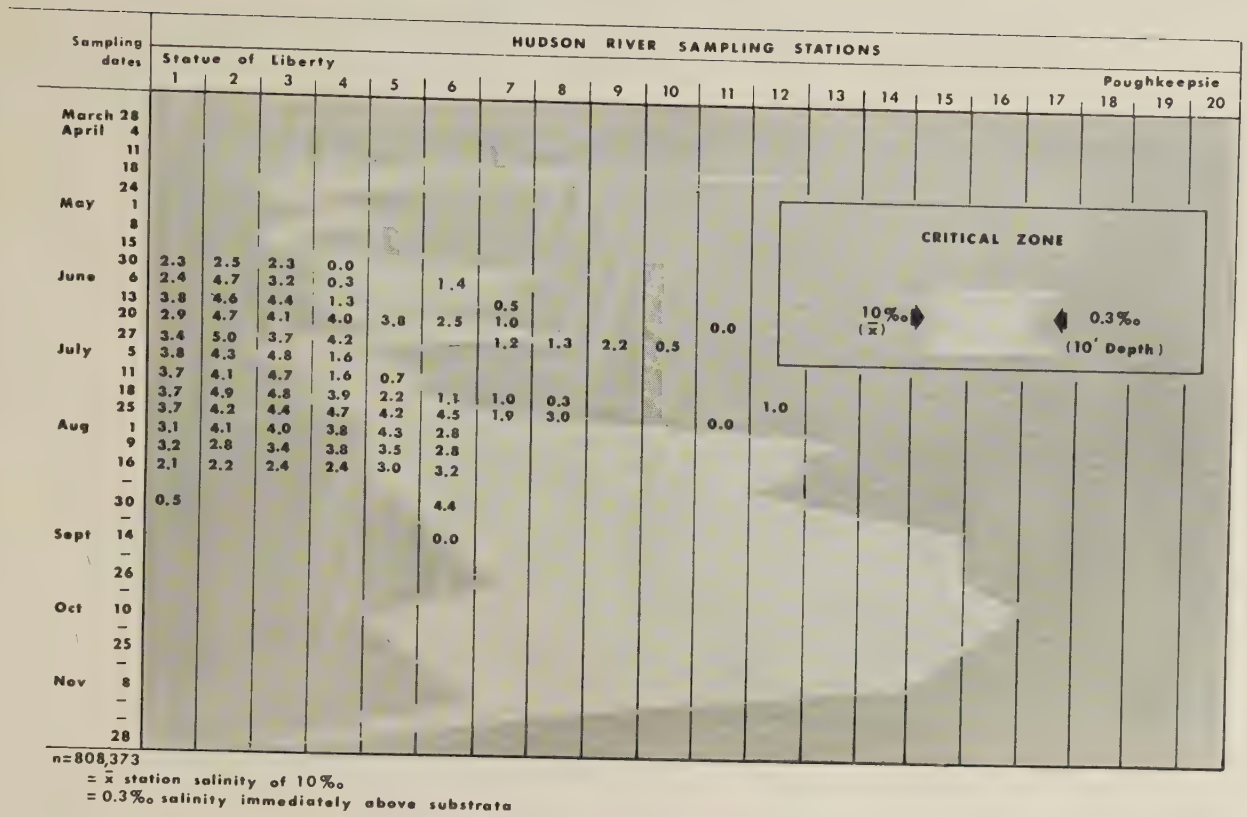


Figure 4. Log numbers of anchovy eggs per 100 cubic meters plotted by sampling station and date (1972).

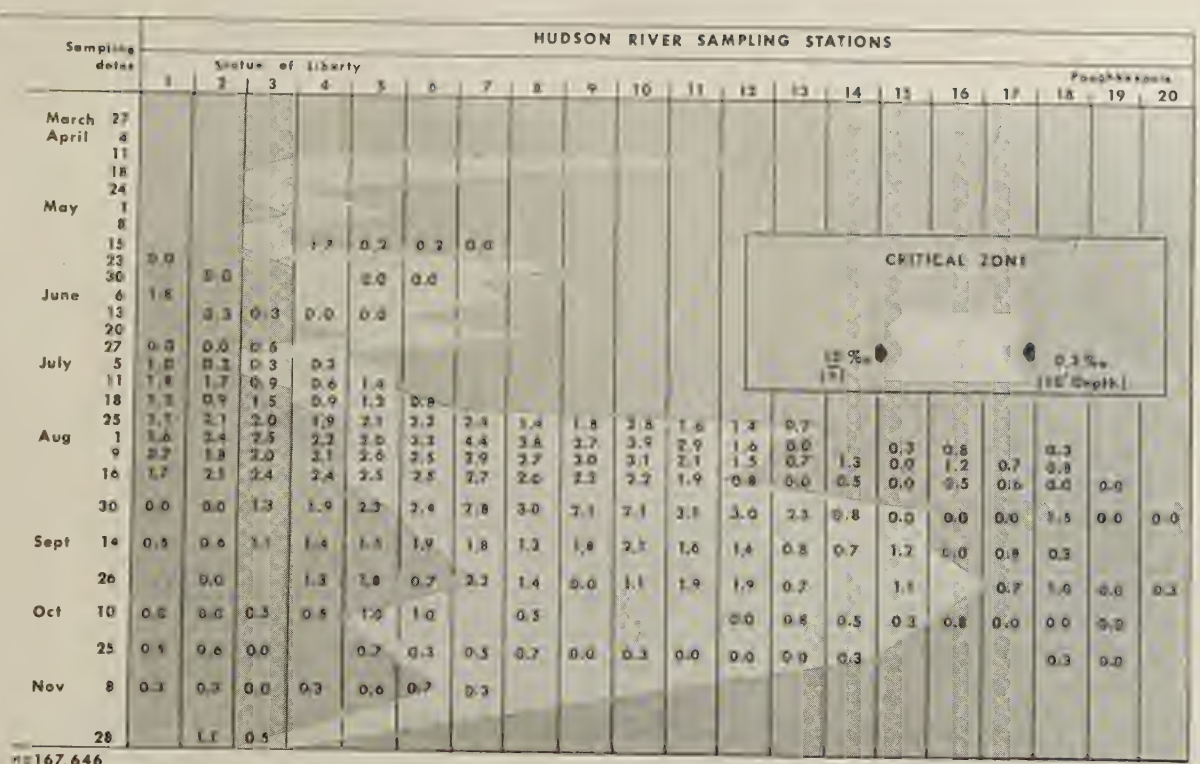


Figure 5. Log numbers of anchovy larvae per 100 cubic meters plotted by sampling station and date (1972)

TABLE 3. MEAN TOTAL LENGTH (IN MILLIMETERS) OF ANCHOVY LARVAE AT EACH SAMPLING STATION IN THE HUDSON RIVER ON SELECTED DATES IN 1972*

Station	Date					
	July 25	August 1	August 8	August 16	Sept. 26	Oct. 10
1	7.8	7.7	8.7	9.3	. .	14.6
2	7.6	8.0	8.1	9.3	12.4	12.9
3	7.7	8.5	10.3	11.2	. .	14.9
4	8.2	9.8	10.0-26.8	9.3	14.7	16.2
5	7.4	8.8	10.1	15.1-30.1	16.4	17.0
6	7.9	9.1	10.3	10.3	14.6	17.1
7	5.7	7.8	9.8	8.8	17.1-28.4	. .
8	7.6	9.4	10.5	11.0	15.0	15.0
9	7.1	9.6	10.9	10.8	12.8	. .
10	5.9	10.6	11.3	10.2	15.0	. .
11	8.6	10.7	12.2-34.4	19.0-34.5	17.9	. .
12	. .	13.0	15.0	13.5-40.6	13.2	30.2
13	5.7	13.9	15.5	16.3	19.7	19.8
14	. .	. .	13.9	15.8	19.0	19.5
15	. .	10.2	15.6	20.3	. .	21.3
16	. .	14.7	13.1	13.2	19.9	17.9
17	. .	15.8	17.2	14.7	15.4	26.5
18	. .	13.9	15.3	11.3	20.0	20.0
19	. .	. .	. .	16.3	17.0	29.3
20	. .	. .	. .	. .	7.7	. .

*Where a range in length is shown, larger value represents individuals from I + age group and smaller value represents individuals from 0 age group.

water temperature declined to the winter level. By late November, juvenile anchovies were found only at Stations 2 and 3 in salt water.

The movement downstream in spring or fall may reflect, to a large degree, the onset of maturity. Fish hatched early in the season may reach maturity before their first winter. Such fish could start a permanent downstream migration before the onset of the cold period, whereas fish hatched late in the season may move up and downstream at least twice before reaching maturity. This pattern would suggest that estuarine-dependent larvae may require a definite period of exposure to the brackish-water environment (possibly its food supply) before reaching maturity regardless of whether the required period takes place in one or two seasons and is separated by a winter. As larvae hatched late in the season, they would migrate upstream to feed, then downstream as water temperatures declined. These larvae would still be immature at the onset of winter. The following spring they would probably move back upstream to feed but return to higher salinity waters to spawn when mature. The basic movement of anchovy larvae to lower-salinity nursery locations followed by the migration of juveniles and adults toward the open sea, as observed in the Hudson River, appears characteristic of the Japanese anchovy (*Engraulis japonica*) as described by Asami (1958) and Hayasi (1961) and is probably characteristic for other members of the family Engraulidae.

The 1972 year class of bay anchovies appears to have been unusually large as trawl collections made by the author each year from 1972 to 1977

produced large catches only in 1972. Therefore, the catch per unit of effort in 1972 may be less significant than the interpretation of the movements of larvae in relation to the hydraulic characteristics of the estuary, the primary force that determines the distribution of estuarine larvae regardless of year-class size.

Striped Bass (*Morone saxatilis*) and White Perch (*Morone americana*) Larvae of striped bass and white perch were found more or less evenly distributed from Station 2 to Station 20. The ratio of white perch to striped bass ranged from 1:1 to 25:1, with an average of 4.2:1 for the total of 20,911 larvae of the genus *Morone* that were examined. Specimens identified only to genus were not included in the calculation. The corresponding ratio for 2,718 larvae of the genus *Morone* examined from upper Chesapeake Bay was 23:1 (Dovel, 1971).[3] It is not known whether this difference in ratio between the two areas is significant. In the Hudson River 40 striped bass larvae ranging from 5.7 to 7.6 millimeters in total length, and 198 white perch larvae ranging from 3.4 to 6.9 millimeters, were found at Stations 2 and 3 off Manhattan during June 1972. Such a distribution will occur following periods of heavy runoff from this watershed during May and June.

The sequence of spawning activities for these two species appears to be reversed in the Chesapeake and Hudson ecosystems. In the Chesapeake white perch spawn from March through June with the peak in April or May at water temperatures of 10° to 15° C. (Dovel, 1971; Mansueti, 1964). On the other hand, striped bass usually start spawning about the middle of April with a peak usually during the last week of April or the first week of May at water temperatures greater than 11° C., and their eggs do not usually occur during March. Thus, in the Chesapeake, the spawning periods of the two species overlap with that of the perch slightly preceding that of the bass.

In the Hudson, striped bass appear to spawn at the same water temperatures as in the Chesapeake, but such temperatures usually occur 2 to 3 weeks later. In 1973, the highest densities of bass eggs were found on May 13 when the mean water temperature was 13.8° C., while the highest densities of white perch eggs occurred during the week of May 27 or about 2 weeks later (Texas Instruments, 1973). Collections of gravid white perch by the author (unpublished data) substantiate the spawning sequence for striped bass in the Hudson estuary. No reason can be given for the apparent reversal of this sequence in the Chesapeake estuary, except to note that in that area white perch do not appear to spawn in the 16.0° to 23.0° C. water temperature range in which spawning takes place in the Hudson.

Blueback Herring (*Alosa aestivalis*) and Alewife (*A. pseudoharengus*) The 32,100 larvae listed for the blueback herring and

[3] The data from which this ratio was derived were collected in the northern part of Chesapeake Bay from the mouth of the Patuxent River to Turkey Point (Dovel, 1971: Figure 1).

alewife in Table 1 were not identified to species due to the time required to examine individual specimens using criteria (Chambers, 1969; Oldmixon, 1964) that are subtle and variable. Although the spawning period of the alewife may commence before that of the blueback herring (Hildebrand and Schroeder, 1928), the two overlap so that the resulting larvae occur concurrently.

Herring larvae first appeared in the area sampled on May 2 when the water temperature was 8.9 ° C. Young of the year occurred in samples until August 9, with the greatest densities occurring during the last week of May and the first two weeks of June. During this period 98.0 per cent of the larvae were found in fresh water, usually between the Tappan Zee Bridge (Station 6) and Poughkeepsie (Station 20). A few, however, were found at all sampling locations south to Station 1 in New York Harbor. The largest individual collections were made between Peekskill (Station 12) and Danskammer Point (Station 19), a reach of the Hudson River with appreciable shoal areas less than 3 meters deep.

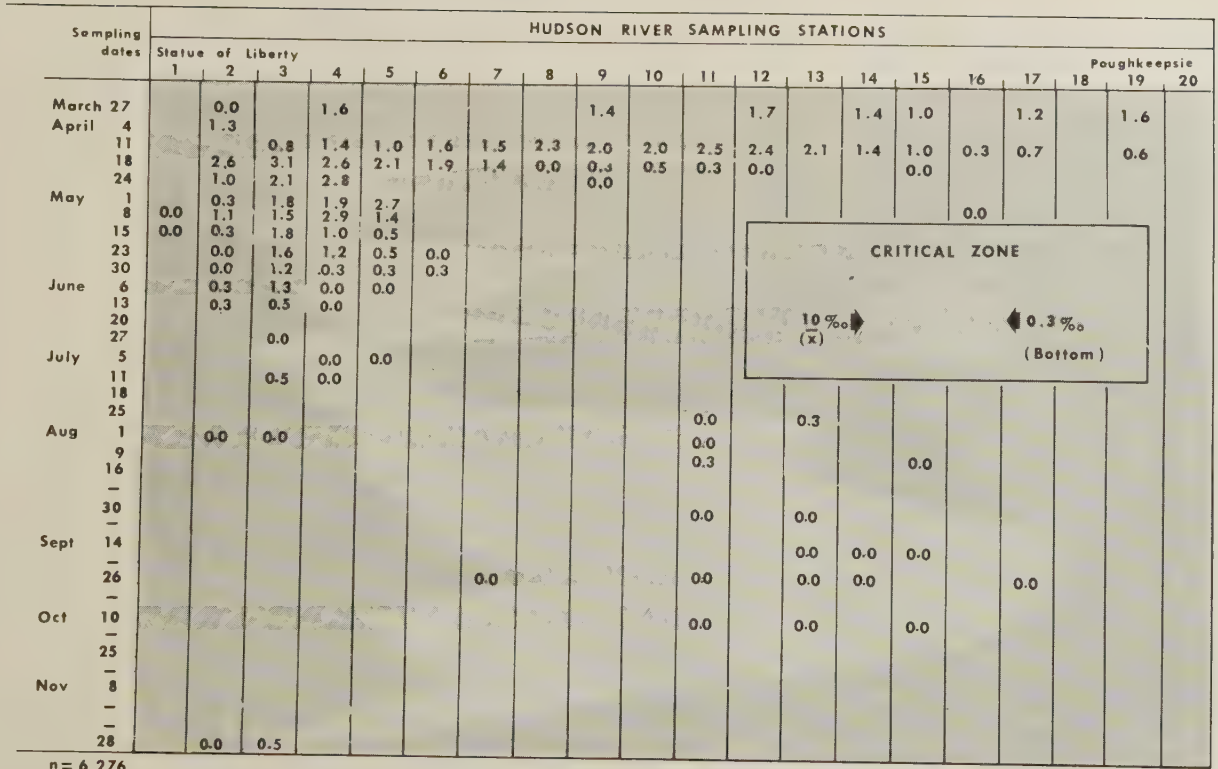
Most of the herring larvae collected, from both fresh and saline areas, were less than 20.0 millimeters in total length. Obviously, recently hatched larvae of the anadromous blueback herring and alewife feed in a freshwater habitat for the first few weeks of life. The subsequent occurrence of these larvae in brackish-water feeding areas would be difficult to monitor due to the low efficiency of ichthyoplankton sampling gear in capturing juvenile fish.

ATLANTIC TOMCOD (*MICROGADUS TOMCOD*) In the Hudson River the tomcod spawns annually in the first few miles of fresh water during the period from December to February, when the water temperature is less than 4 ° C. After spawning, the adults move downriver to Haverstraw Bay and the Tappan Zee, where they spend several weeks before moving toward the mouth of the stream.

Newly-hatched larvae apparently move downstream to low-salinity waters (less than 10.0 ppt) south of the Tappan Zee and then return upstream with the brackish water during the late summer (Figure 6). With the onset of winter, the few young-of-the-year tomcod collected occurred in warmer, more saline waters. Much of this movement may be attributed to the transport of planktonic larvae by water currents in a manner similar to that described for the by anchovy.

CONCLUSIONS

The significant factors recognized in comparing the ichthyoplankton of the Hudson and Patuxent estuaries are: (1) the similarity of the species inhabiting the two ecosystems; (2) the lower abundance in the Hudson of individuals representing dominant estuarine species common to both ecosystems; and (3) the apparent importance of the physical forces within an estuarine system in determining the distribution and movement of lar-



n = 6,276

= $\bar{x}$ station salinity of 10 ‰

= 0.3 ‰ salinity immediately above substrata

Figure 6. Log numbers of tomcod larvae per 100 cubic meters plotted by sampling station and date (1972).

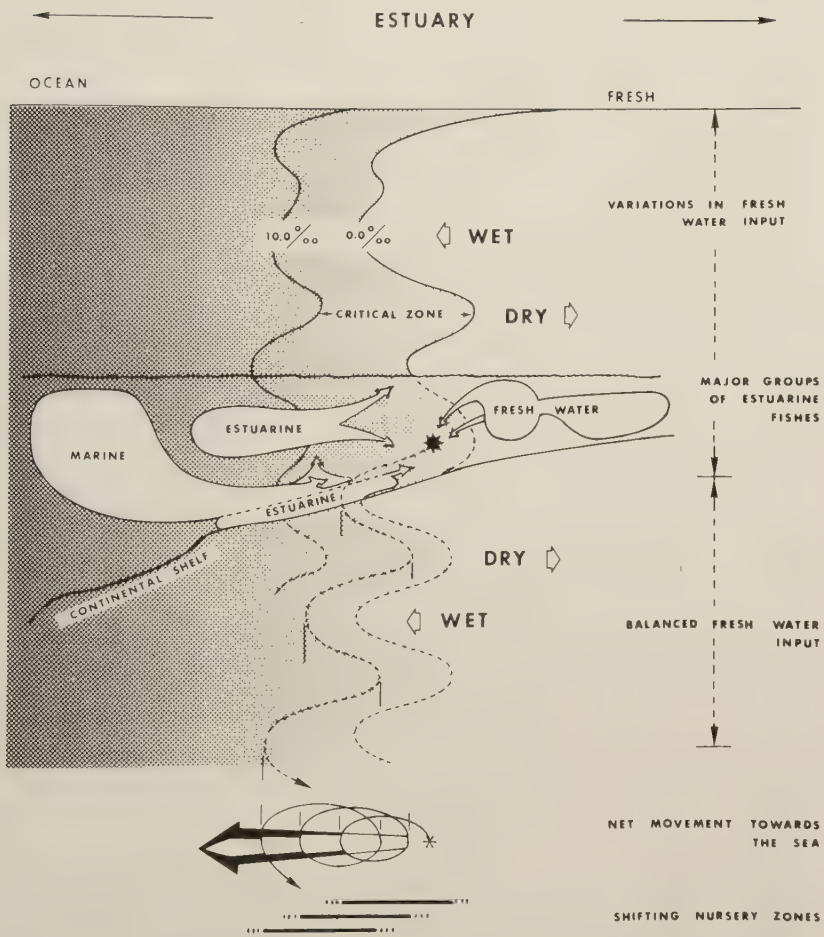


Figure 7. Concept of movement of estuarine-dependent fish larvae through the low-salinity "critical zone" and toward the ocean as the fish grow. The movements of individual fish (*) show a gradually changing relationship to the salt front, which results in a downstream shift of nursery zones for succeeding stages of development.

val fish. Figure 7 presents the concept of movement of estuarine-dependent fish larvae through the "critical zone" and toward the ocean as the fish grow. The deposition of eggs from some marine, estuarine and freshwater anadromous spawners occurs at locations from which the planktonic larvae will be carried first toward a brackish-water nursery area. In subsequent movements, progressively more nektonic, the developing fish move toward more saline feeding areas.

The input of fresh water upstream causes the transport of planktonic larvae to be characterized by erratic, oscillatory motion directly responsive

to the movement of the salt front as influenced by variations in precipitation. During wet and dry seasons, as well as during ebb and flood tides, the salt front will move downstream and upstream, respectively, constantly changing the character, size and location of the critical nursery zones (Figure 7). The concept of shifting nursery zones as influenced by the position of the salt front should be helpful in assigning values to parts of the estuarine environment that support fisheries resources along the Atlantic coast of North America.

Based on data gathered from the Hudson estuary by the author (1972-1977) and the investigations of Texas Instruments, Inc. (Texas Instruments, 1976), it is the opinion of the author that the section of the Hudson River between Piermont and Stony Point (Tappan Zee and Haverstraw Bay) could be considered the heart of the primary nursery area which extends from Manhattan to the vicinity of Coxsackie about 20 miles south of Albany. It is in this area that the survival of every year class of anadromous striped bass, American shad and Atlantic sturgeon produced in the Hudson River is determined. Likewise, although anadromous clupeids hatch and spend some time upstream in fresh water areas, they too move south into the primary area before leaving the river in the fall.

There are many potential sources of pollutants in the Hudson which can endanger the vitality of the primary nursery area. Nevertheless, the biota of this estuarine system is presently viable and has remained so during recent years when the river was considered possibly beyond reclamation (Cronin, 1967). The total productivity of the estuarine portion of the river has been poorly understood and perhaps judged on the basis of the characteristics of a few popular species representing organisms of high trophic levels.

Major estuarine systems such as the Hudson River make a direct and substantial contribution to biological resources, primarily fish, harvested over the continental shelf. This contribution, in the case of the Hudson, involves: (1) the direct recruitment of estuarine-reared fish to ocean populations (menhaden, sturgeon, striped bass, smelt); (2) the flushing of nutrient materials from land to support photosynthesis at sea; and (3) the movement of forage species out of the system (anchovy, alewife, blueback herring, tomcod). Fisheries of Georges Bank, the Gulf of Maine, Long Island Sound and the mid-Atlantic Bight are undoubtedly benefited by biological conditions and nutrient contributions in the Hudson estuary.

LITERATURE CITED

Anonymous. 1968. Zooplankton sampling. Monographs on Oceanographic Methodology 2, United Nations Educ., Sci. and Cultural Organ.

Asami, T. 1958. On the patterns of development and growth of Japanese anchovy along the coast of Nankai and Nankai regions of Japan. Nankai Reg. Fish. Res. Lab., Rept. 7:1-8.

BAILEY, R. M., J. E. FITCH, E. S. HERALD, E. A. LACHNER, C. C. LINDSEY, C. R. ROBINS AND W. B. SCOTT. 1970. A list of common and scientific names of fishes from the United States and Canada (3rd ed.). Am. Fish. Soc., Spec. Publ. 6.

CARLSON, F. T., AND J. A. MCCANN. 1969. Evaluation of a proposed pump-storage project at Cornwall, New York, in relation to fish in the Hudson River: Hudson River Fisheries Investigations 1965-1968 (A. C. Jensen, Ed.). Prepared by the Hudson River Policy Committee, A. G. Hall, Chm.

CHAMBERS, J. C. 1969. Methods of distinguishing larval alewife (*Alosa pseudoharengus*) from larval blueback herring (*Alosa aestivalis*). M.S. thesis. William and Mary College, School of Marine Science.

CRONIN, L. E. 1967. The role of man in estuarine processes. In: Estuaries (G. H. Lauff, Ed.). Am. Assoc. Advancement Sci., Publ. 83:667-689.

DOVEL, W. L. 1964. An approach to sampling estuarine macroplankton. Chesapeake Sci. 5:77-90.

_____ 1971. Fish eggs and larvae of the upper Chesapeake Bay. Nat. Res. Inst., Univ. Maryland, Contrib. 460, Spec. Sci. Rept. 4.

HAYASI, S. 1961. Fishery biology of the Japanese anchovy, *Engraulis japonica* (Houttuyn). Tokai Reg. Fish. Res. Lab., Bull. 31:145-268.

HILDEBRAND, S. F., AND W. C. SCHROEDER. 1928. Fishes of Chesapeake Bay. Bull. U.S. Bur. Fish., Vol. 43 (Pt. 1).

KOTT, P. 1953. Modified whirling apparatus for the subsampling of plankton. Australian Jour. Marine and Freshwater Research 4:387-393.

MANSUETI, R. J. 1964. Eggs, larvae, and young of the white perch, *Roccus americanus*, with comments on its ecology in the estuary. Chesapeake Sci. 5(1-2):3-45.

MASSMAN, W. H., E. C. LADD AND H. N. MCCUTCHEON. 1952. A biological survey of the Rappahannock River, Virginia. Virginia Fish. Lab., Spec. Sci. Rept. 6 (Pt. 1).

NEW YORK POWER POOL. 1974. Map (prepared by National Survey, Chester, Vt.)

OLDMIXON, E. 1964. Valid criteria for distinguishing the young stages of five Chesapeake Bay clupeids. Chesapeake Biol. Lab., Univ. Maryland. (Summer student project report, August 1964).

RATHJEN, W. F., AND L. C. MILLER. 1957. Aspects of the early life history of the striped bass (*Roccus saxatilis*) in the Hudson River. N.Y. Fish and Game Jour. 4:43-60.

TALBOT, G. B. 1966. Estuarine environmental requirements and limiting factors for striped bass. In: A symposium on estuarine fisheries (Ronald F. Smith, Ch.). Am. Fish. Soc., Spec. Publ. 3. (supplement to Trans. Am. Fish. Soc. Vol. 95)

TEXAS INSTRUMENTS. 1973. Hudson River program fisheries data summary May-July. Prepared for Consolidated Edison Company of New York.

_____ 1976. Fisheries survey of the Hudson River March-December 1973, Vol. IV. Revised edition June 1976. Prepared for Consolidated Edison Company of New York.

TOFFLEMIRE, T. J., AND L. J. HETLING. 1969. Pollution sources and loads in the lower Hudson River. In: Hudson River Ecology (C. P. Howells and G. J. Lauer, Ed.):78-146. Proceeding of a symposium sponsored by N.Y. Univ. Inst. Environ. Med. and others. (Printed by N.Y.S. Dept. Environ. Cons.)

TRESSELT, E. G. 1952. Spawning grounds of the striped bass, *Roccus saxatilis* (Walbaum), in Virginia. Bull. Bingham Oceanog. Coll. 14(1):98-100.

WILBORG, K. F. 1951. The whirling vessel, an apparatus for the fractioning of plankton samples. Fiskeridirektoratets Skrifter serie Harunderskelser 9:1-16.

A TECHNIQUE FOR EXCAVATING RED FOX DENS[1]

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ABSTRACT

A method of excavating red fox dens with the aid of a wire ferret and net bags is described. A total of 72 dens were located and excavated on a 100-square mile area in Central New York, and nine adult females and 225 pups were captured, a few more than once. A mean of 4.5 fox pups were captured per successful excavation. Dens were reconstructed after being excavated, and there was no significant difference between the rate of reoccupation for excavated and unexcavated dens. Because of the contagious and fatal nature of sarcoptic mange in red foxes, a strict procedure was developed to completely decontaminate or replace all tools and other equipment used.

Capturing red foxes (*Vulpes fulva*) at dens is an important means of obtaining data on their denning habits as well as dispersal, reproduction and mortality rates, and excavation has been used for this purpose in many studies. Excavation has also been suggested as a possible population control measure. However, little has been written specifically about techniques for capturing red foxes at dens. One of the earliest was to block all den entrances but one and then trench out the entire tunnel system from the unblocked entrance (Eadie, 1954; Garlough, 1945). Jensen (1973), Maki (1951) and Marcstrom (1968) used small dogs to drive fox pups from dens, or to bark at pups in dens and thus localize them for excavation. Storm and Dauphin (1965) described and used a wire ferret for driving red foxes out of dens. Allen (1971) dug foxes out of dens by pushing a conduit into a tunnel and then digging a shaft down to intersect the tunnel at the end of the conduit, repeating the procedure for the entire length of the tunnel system. Sargeant (in conversation) suggested a procedure parallel to Allen's, using a wire ferret instead of a conduit. Pils and Martin (1978) used a wire ferret equipped with a radio transmitter to locate tunnels.

The excavating technique described here was developed by the State Department of Environmental Conservation for capturing red foxes at dens on a study area in Cayuga County (N.Y.). The area comprised 100 square miles in the towns of Brutus, Cato, Conquest, Mentz and Throop.[2] The work was carried on from 1972 to 1977.

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[1]The authors are grateful to Dr. R. E. Chambers, Dr. George Mattfeld and Ward B. Stone for reviewing and criticizing the manuscript and to Ernest Saggese (deceased), Elmer Davies, Stewart Van Wie, Howard Parish, Stanley Butkas, Alan Martel, Gary Golja, Greg Fuerst and Cecil Barrett for assistance in excavating dens, as well as to Alan Sargeant for advice on den excavation.

[2]Several dens excavated were actually across the line (less than 1/2 mile) in Wayne County.

PROCEDURE

The procedure consisted of locating red fox dens and excavating them in order to capture the foxes using them. After a den had been excavated, it was reconstructed so that it could be reoccupied by foxes, and all tools and other equipment used in the work were decontaminated.

LOCATING DENS

Field searches for red fox sign and active dens on the study area were made from February through June each year. All known denning areas and all areas containing fox sign were searched, as well as areas where hunters, trappers or landowners reported finding a den or seeing fox pups and areas that showed repeated use during spring roadside track counts. All searchers were technicians familiar with red fox denning habits.

In March and April of 1972 and 1973, a helicopter flying 40-60 miles per hour at an altitude of 200 feet was used to find active dens. Also in March and April of 1973, 10 one-square-mile units were randomly selected and systematically searched by college students and project technicians walking across them at 40-yard intervals.

A den was considered occupied if foxes were seen at or near it or tracks, droppings, odors, food litter, etc. indicated that foxes were using it. Signs of red fox den occupation have been described by Garlough (1945), Sargeant et al. (1975), Scott (1941), Scott and Selko (1939) and Sheldon (1950). Prior to the time of excavation, searchers did not approach a den any closer than was necessary to determine if it was occupied.

EXCAVATING DENS

Equipment used to excavate dens included: net bags to cover all entrances; two or three blunt wire ferrets; round-pointed shovels with various handle lengths; a bow saw or axe for cutting roots and material for reconstructing the tunnels; a cage for holding the fox pups; and flashlights for looking down the tunnels. In addition, all workers were equipped with heavy rubber gloves, caps, coveralls and rubber boots.

An occupied den was approached as quickly and quietly as possible by a team of three or four workers. A net bag was immediately placed over each of the den entrances (Figure 1). These bags were made of 1-inch-square-mesh cotton or nylon netting and at least 5 feet long by 3 feet wide. An expandable (14- to 22-inch diameter) wire hoop was sewn into the open end of the net bag. The bag was anchored by pinning the wire hoop to the ground around the den entrance, and the top was lightly suspended by twigs allowing unobstructed movement of foxes from the den entrance to the closed end.

A blunt wire ferret was cranked and pushed into a den entrance until foxes were heard vocalizing inside, or the ferret could not be advanced any

Figure 1. A net bag in position over a fox den entrance.

further, or it came out another entrance or it hit something such as nesting material or a food item that the excavators wanted to examine. Then, the ferret was withdrawn about a foot and cranked in place while the crew listened and felt the ground to find the strongest vibrations. Once the approximate location was determined, a shaft was dug down to expose the tunnel adjacent to the ferret. Then the shaft was enlarged to enable an observer to look down the length of the tunnel in both directions. Using a flashlight, the observer looked for foxes and fox sign. Any additional tunnels observed from the shaft were also ferreted and visually searched.

This procedure was repeated until a shaft had been dug at the end of every tunnel. The entire known tunnel system was then ferreted from the end of each tunnel back to the den entrances to help locate additional side tunnels and to drive foxes into the net bags. Additional shafts were dug to intersect sections of tunnel that could not be observed from existing shafts, especially if that section contained more fox sign than the rest of the den complex.

RECONSTRUCTING DENS

After each tunnel of the den was ferreted in both directions and all the foxes that had been located were captured, the den was reconstructed so that it could be reused by foxes. Before the shafts were refilled, the tunnels they had cut were rebuilt. To accomplish this, a hollow was dug in the shaft wall to create a passageway which would reconnect the tunnel system. A solid lean-to of old boards or wood split from wind-thrown trees was placed over these passageways in such a manner as to provide protection from the back-filled soil.

DECONTAMINATION

In order to prevent the possible spread of disease, all personnel involved in excavating dens were required to wear coveralls, hats, rubber boots and gloves, all of which were thoroughly disinfected and laundered after each excavation. All tools were soaked in a disinfectant such as Vestal-10[3] and then steam cleaned. The motor vehicles used to transport crews and equipment from the dens were also steam cleaned after each excavation. All net bags were soaked in disinfectant and dried before being reused.

EVALUATION OF TECHNIQUE

The results of the work done and evaluation of the methods used are discussed under the same topics as for the procedure.

LOCATING DENS

A total of 72 red fox dens were found. According to the different methods of finding dens, 31 (43.0 per cent) were in areas that were known to have been previously used by denning foxes, 26 (36.1 per cent) were in areas where only fox sign had been noted, and 11 (15.3 per cent) were in areas where hunters, trappers or landowners reported a den or seeing fox pups. Two dens (2.8 per cent) were found in areas that had shown repeated use during spring roadside track counts, and two (2.8 per cent) were found as a result of intensive searching on the 1-square-mile randomly chosen units. The latter two represented 13.3 per cent of the 15 dens found in 1973 but required about 150 mandays of effort. Although new dens as well as previously known ones were located by aerial observation, aerial observers were unable to find all of the known dens.

Most of the dens were in sandy soils such as those suggested by Sheldon (1950) and Layne and McKeon (1956), but attempts to associate them with mapped soil types (Hutton, 1971) proved unsuccessful because the study area either had a sandy subsoil or was muck with small unmapped sandy spots and artificially raised features such as dikes.

[3]A product of Vestal Laboratories, Division of Chemed Corp., St. Louis, Mo. 63110.

Excavating Dens

In this study, the major purpose of excavating dens was to capture foxes. Therefore, ferreting was begun at a den entrance that showed heavy use, and the fox sign was followed through the tunnel system to the foxes. Gray puppy underfur clinging to the tunnel walls, puppy droppings and fresh food items were often found in the vicinity of the pups. Pups less than 2 weeks old would usually be found in a pile as noted by Fox (1971). Such a pile of pups could move up and down the tunnel in a mass leaving puppy fuzz (the short gray puppy underfur) on the walls and even the ceiling of the tunnel. As the pups became older puppy fuzz became less significant, and fresh puppy droppings and fresh food became the best indicators of their presence in the den. It was important to look down the tunnel exposed by a shaft before doing any additional ferreting because excessive cranking of the ferret would mask much of the fox sign. Because of the numerous turns and changes in elevation of the tunnels, any optical aid would be very valuable if it was practical to decontaminate.

The function of the wire ferret was to locate the tunnel system and to drive foxes into the net bags, but it was never used to entangle or otherwise capture foxes. The net bags functioned as trapping devices when they were suspended lightly enough to allow the net to fall as the fox struggled to push through the mesh at the closed end (Figure 1). Net bags were sometimes left on den entrances overnight, and captures were quite common if the den had been at least partly excavated. However, where excavation had not been started, only one such capture was made. It is interesting that on two occasions when net bags were left covering all the den entrances overnight, an adult fox dug into the den and removed the pups.

Except in 1973 and 1976, foxes were captured at more than 70 per cent of the excavated dens (Table 1). In 1973 methods of locating and excavating dens were still being refined, and in 1976 a shortage of personnel made it necessary to delay excavation until weeks after a den had been found. The best results were obtained when occupied dens were excavated the day after they were found.

Only nine adult females were captured by excavation, and they were all taken before the third week in April, probably because vixens usually spend less time inside the den after that. Adult males apparently spend little time in dens since none was captured by excavation during this study. The proportion of pups captured in net bags rose from zero in March to nearly 20 per cent in April and to more than 60 per cent in May and 100 per cent in June (Table 2). This reflects increasing mobility and a tendency for older pups to leave the den when threatened. Also, the number of pups captured per successful excavation decreased after mid-May, perhaps because of pups starting to spend more time outside the dens or because of litters splitting up and concurrently occupying more than one den site.

TABLE 1. DEGREE OF SUCCESSFUL EXCAVATION OF RED FOX DENS ON A 100-SQUARE-MILE STUDY AREA IN CAYUGA COUNTY, NEW YORK, 1973-1977

Year	Excavations		
	Total	Successful*	
		Number	Per cent
1973	15	8	53.3
1974	28	22	78.6
1975	26	19	73.1
1976	3	1	33.3
1977	12	10	83.3
Total	84	60	71.4

*An excavation was considered successful when at least one fox was captured.

TABLE 2. RED FOX DENS EXCAVATED AND PUPS CAPTURED ON STUDY AREA* FROM MARCH THROUGH JUNE, 1973-1977

Period	Dens excavated		Pups captured					
				Number per successful excavation	By hand		In net bags	
	Total§	Successful	Total†		Number	Per cent	Number	Per cent
March 1-31	2	1	6	6.0	6	100.0	0	0.0
April								
1- 7	7	3	15	5.0	15	100.0	0	0.0
8-15	13	10	43	4.3	40	93.0	3	7.0
16-22	15	12	57	4.8	53	93.0	4	7.0
23-30	11	9	52	5.8	42	80.8	10	19.2
May								
1- 7	12	5	24	4.8	7	29.2	17	70.8
8-15	6	5	23	4.6	11	47.8	12	52.2
16-23	10	10	34	3.4	19	55.9	15	44.1
24-31	7	4	13	3.3	5	38.5	8	61.5
June 1-30	1	1	4	4.0	0	0.0	4	100.0
Total	84	60	271	4.5	198	73.1	73	26.9

*100 square miles in Cayuga County, N.Y.

§There were 72 different dens excavated, but some more than once.

†Includes 255 captured for the first time and 16 recaptures.

Foxes may have been present in some of the excavated dens where none was captured, although none was ever observed at these dens on the day they were excavated. On four occasions, litters that had been dug out and tagged earlier were re-excavated, and 14 (93.3 per cent) of the 15 pups originally tagged were recaptured. At the same time only three untagged pups were captured, indicating a high rate of initial capture.

The mean number of pups captured per successful den excavation was 4.5. Since a mean of 6.0 placental scars (counting all present) was recorded per vixen collected on or near the study area (unpublished project data), 75 per cent of the pups may have been captured at the successfully excavated dens. Success may have been ever higher because some resorption, still births or early pup mortality had probably taken place. Storm et al.

(1976) reported 3.5 pups per den where pups were captured and a mean of 7.1 placental scars (counting all present) per vixen collected.

Den excavation involved long days of hard work, parallelling the experience of Sheldon (1949). Tree roots posed no problems, but digging shafts and locating the wire ferret in tunnels was difficult in hardpan and layers of clay or gravel.

Reconstructing Dens

Sheldon (1949) also stated that one of the disadvantages of digging out fox dens to capture pups was "that the habitat is spoiled". Sargeant et al. (1975) stated that excavated dens were probably less attractive in subsequent years. However, Layne and McKeon (1956) mentioned a gray fox (*Urocyon cinereoargenteus*) den and Pils and Martin (1978) mentioned red fox dens that had been reoccupied after having been dug out in previous years. Although the number of dens was not a limiting factor to fox productivity on the study area (unpublished project data), the rate of reoccupation for excavated dens was not significantly different ($P > 0.05$) from that for unexcavated dens.

Decontamination

Decontamination procedures were developed to prevent the spread of any disease as a result of den excavating. Pesticides were not used because of the repeated exposure of humans and animals to the decontaminated equipment. Field experience of project personnel as well as that of other investigators suggested that sarcoptic mange would be the principal concern.

Parks (1968) reported that sarcoptic mange had effectively reduced red fox populations in areas of New York, and Stone et al. (1974) found mange in red foxes to be widespread in the State including the Cayuga County study area. Pryor (1956) noted its extent in Pennsylvania. Olive and Riley (1948) and Trainer and Hale (1969) reported that mange may regulate red fox populations. Stone et al. (1972b) reported that each of 16 red foxes experimentally infested with sarcoptic mange died of that disease. These records indicate that sarcoptic mange is an important mortality factor in red foxes.

The causative agent of sarcoptic mange, *Sarcoptes scabiei* var. *canis*, could be transferred to and by den excavators or their equipment by several routes. Direct handling of infected animals posed the greatest threat. Zeh (1974) found up to 1,877 mites per square centimeter of skin on mangy red foxes from New York State. He also estimated that the total mite population on a mangy fox could range into the millions. There are reports that illustrate possible routes of indirect contamination. Brovkina (1961) cited frequent scabies in Russian foxes where their dens were used

repeatedly. Burrows (1968) and Failor (1971) suggested that dens can be contaminated by mangy foxes. Zeh (1974) found mange mites on ticks and fleas taken from mangy foxes. Burrows (1968) and Stone et al. (1972a) reported that mange mites can live up to 10 days apart from a host. Therefore, a den could be contaminated for 10 days after it was occupied by a mangy fox and contaminated equipment might carry live mites for that long. Gerasimoff (1953) experimentally infested red foxes with mange by placing 10 to 20 mites in their dens. He also reported that a red fox died of mange after being inoculated with a single female larval mite. Therefore, if contaminated equipment transferred just one female mite, it could cause the spread of mange to another den of foxes.

Sarcoptic mange is often difficult to detect during its early stages of infestation (Stone et al., 1974), and any recently or currently occupied den could have been infested with it. Also, Stone et al. (1976) reported several cases in which humans contracted sarcoptic mange. Therefore, after each excavation extreme care was taken to decontaminate or replace all tools, equipment and other material taken to any den, as described under procedure. A steam cleaner was used because Mallanby (1972) reported that sarcoptic mange mites cannot withstand high temperatures and die within 10 minutes at 120° F. The decontamination process limited a team of workers to one excavation per day. The precautions appear to have been successful. Dens of mangy foxes were excavated, but there was no indication of any tagged foxes having contracted sarcoptic mange at the time of excavation, and no member of a den excavation team contracted sarcoptic mange.

LITERATURE CITED

ALLEN, S. H. 1971. More on "Big Red". North Dakota Outdoors 34:8-10.

BROVKINA, E. T. 1961. Censusing foxes and badgers by counting burrows in commercial hunting tracts in central R.D.F.S.R.—in Europe. In: Organization and Methods of Censusing Terrestrial Vertebrate Faunal Resources (Yu. A. Isakov, ed.). Moscow Naturalist's Soc. Instit. Geog., Academy of Sciences, U.S.S.R.: 34-35.

BURROWS, R. 1968. Wild Fox. Taplinger Publ. Co., New York.

EADIE, R. W. 1954. Animal Control in Field, Farm and Forest. MacMillan Co., New York.

FAILOR, P. L. 1971. Pennsylvania trapping and predator control methods. Penn. Game Comm., Harrisburg, Penn.

FOX, M. W. 1971. Behavior of Wolves, Dogs and Related Canids. Harper and Row, New York.

GARLOUGH, F. C. 1945. Capturing foxes. U.S. Dept. Int., Fish and Wildl. Serv., Circ. 8.

GERASIMOFF, YU. A. 1953. Mange in wild foxes. Canada Dept. Northern Affairs and Natl. Res. (Translation of Russian game reports, Vol. 3, 1958).

HUTTON, F. Z., JR. 1971. Soil survey of Cayuga County, New York. U.S. Soil Cons. Serv. in cooperation with Cornell Univ. Agric. Exp. Sta.

JENSEN, B. 1973. Movements of the red fox (*Vulpes vulpes* L.) in Denmark investigated by marking and recovery. Danish Rev. Game Biol. 8(3):3-17.

LAYNE, J. N., AND W. H. MCKEON. 1956. Notes on red fox and gray fox den sites in New York. N.Y. Fish and Game Jour. 3(2):248-249.

MAKI, T. V. 1951. How to control the fox population. Suomen Riista 6:136-148, 192.

Marcstrom, V. 1968. Tagging studies on red fox (*Vulpes V.*) in Sweden. Viltrevy 5(4):102-117.

Mellanby, K. 1972. Scabies. Biddles LTD, Guildford, Great Britain.

Olive, J. R., and C. V. Riley. 1948. Sarcoptic mange in the red fox in Ohio. Jour. Mammal. 29(1):73-74.

Parks, E. 1968. Control of rabies in wildlife. N.Y. Fish and Game Jour. 15(1):98-111.

Pils, C. M., and M. A. Martin. 1978. Population dynamics, predator-prey relationships and management of the red fox in Wisconsin. Wis. Dept. Nat. Res., Tech. Bull. 105.

Pryor, L. B. 1956. Sarcoptic mange in wild foxes in Pennsylvania. Jour. Mammal. 37(1):90-93.

Sargeant, A. B., W. K. Pfeifer and S. H. Allen. 1975. A spring aerial census of red foxes in North Dakota. Jour. Wildl. Mgt. 39(1):30-39.

Scott, T. G. 1941. A method for estimating the red fox population. Iowa State Coll. Jour. Sci. 15(2):155-159.

Scott, T. G., and L. F. Selko. 1939. A census of red foxes and striped skunks in Clay and Boone Counties, Iowa. Jour. Wildl. Mgt. 3(2):92-98.

Sheldon, W. G. 1949. A trapping and tagging technique for wild foxes. Jour. Wildl. Mgt. 13(3):309-311.

_____ 1950. Denning habits and home range of red foxes in New York State. Jour. Wildl. Mgt. 14(1):33-42.

Stone, W. B., E. Parks and B. L. Weber. 1972a. The little foxes. N.Y.S. Conservationist 26(4):8-9, 47.

Stone, W. B., E. Parks, B. L. Weber and F. J. Parks. 1972b. Experimental transfer of sarcoptic mange from red foxes and wild canids to captive wildlife and domestic animals. N.Y. Fish and Game Jour. 19(1):1-11.

Stone, W. B., B. F. Tullar, Jr., J. B. Zeh and B. L. Weber. 1974. Incidence and distribution of mange mites in foxes in New York. N.Y. Fish and Game Jour. 21(2):163-166.

Stone, W. B., D. E. Roscoe and B. L. Weber. 1976. Spontaneous and experimental transfer of sarcoptic mange mites from red foxes to humans. N.Y. Fish and Game Jour. 23(2):183-184.

Storm, G. L., and K. F. Dauphin. 1965. A wire ferret for use in studies of foxes and skunks. Jour. Wildl. Mgt. 29(3):625-626.

Storm, G. L., R. D. Andrews, R. L. Philips, R. A. Bishop, D. B. Siniff and J. R. Tester. 1976. Morphology, reproduction, dispersal, and mortality of midwestern red fox populations. Wildl. Monog. 49.

Trainer, D. C., and J. B. Hale. 1969. Sarcoptic mange in red foxes and coyotes of Wisconsin. Bull. Wildl. Disease Assoc. 5(4):387-391.

Zeh, J. B. 1974. Infestations of sarcoptic mange on the red fox in New York. N.Y. Fish and Game Jour. 21(2):182-183.

NATURAL REPRODUCTION AND JUVENILE ECOLOGY OF PACIFIC SALMON AND RAINBOW TROUT IN TRIBUTARIES OF THE SALMON RIVER, NEW YORK[1]

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ABSTRACT

The extent of natural reproduction of Pacific salmon and rainbow trout was examined from May through November in 1977 in five tributaries of the Salmon River in New York. Juvenile coho salmon and rainbow trout were found in all the streams studied. Variation in fry density between streams was much greater for the salmon than for the trout. Orwell Brook contained the highest density of coho fry. Rainbow trout fry were abundant in four of the five streams. Natural reproduction of chinook salmon was minimal in the study streams, but chinook smolts were seined along the shore of Lake Ontario near the Salmon River estuary during May, June and early July in 1977 and 1978. Peak emergence of coho salmon occurred about June 1, but emergence of rainbow trout fry appeared to extend from early June to August. In all the streams, most coho salmon evidently left during their first year, while virtually all the rainbow trout left before the age of two. However, migration of juvenile salmonids may have occurred before sampling was begun during mid-May in 1977.

Historically, the Atlantic salmon (*Salmo salar*) was the only migratory salmonid indigenous to Lake Ontario. In New York, the species inhabited all tributaries of Lake Ontario except the Genesee River. The Salmon River, in Oswego County, was considered the best salmon stream in the State. However, by 1900 Atlantic salmon were extinct in Lake Ontario. Their decline has been attributed to mill dams, deforestation, overfishing and pollution (Parsons, 1973). As a result, exhaustive efforts have been made to reestablish this salmon and other migratory salmonids in Lake Ontario and throughout the Great Lakes.

Rainbow trout (*Salmo gairdneri*) were first stocked in the Great Lakes in 1895 (Scott and Crossman, 1973). Extensive natural reproduction was observed as early as 1939 in the Salmon River system of Lake Ontario (Greene, 1940). MacCrimmon and Gots (1972) reported that rainbow trout populations had been sustained for many years by natural reproduction in Canadian tributaries of Lake Ontario.

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The introduction of Pacific salmon in Lake Ontario began with the planting of chinook salmon (*Oncorhynchus tshawytscha*) in 1873. Coho salmon (*O. kisutch*) were not introduced until 1968 when the New York State Conservation Department (now Department of Environmental Conservation) began its salmonid restoration program for Lake Ontario (Parsons, 1973). Severe predation by the sea lamprey (*Petromyzon marinus*) resulted in low survival of these fish. However, programs begun in 1971 to control the sea lamprey in Lake Ontario have sufficiently reduced their populations to bring about higher survival of stocked salmonids.

The increased survival of Pacific salmon and rainbow trout has resulted in large spawning runs to tributary streams during the fall and spring. Knowledge of the reproductive success of these fish is of major importance as a tool for proper management of this valuable resource. However, prior to the present study the extent and degree of success in the Salmon River system was unknown. The objectives of the study were to determine the extent of natural reproduction in certain tributaries of the Salmon River and to examine aspects of the juvenile ecology of these fish.

METHODS AND MATERIALS

The Salmon River system in the Tug Hill region of New York was selected because of yearly returns of adult anadromous salmonids and the apparent quantity and quality of suitable spawning and nursery areas. Tug Hill represents a transitional zone between the hardwood forests of the Allegheny Plateau to the south and the hardwood and coniferous forests of the Adirondack Mountains to the east. The region is characterized geologically by relatively simple bedrock features, with nearly all of the area being underlain by sedimentary rocks comprising sandstones, siltstones, shales and limestones. Topography generally is gentle and lacks extreme features, except for the eastern escarpment and some deeply cut stream channels. The land rises gradually from a low elevation of about 75 meters at the shore of Lake Ontario to over 640 meters at the eastern side of the central upland area (Leaf and Wittwer, 1974).

With the assistance of personnel from the State Department of Environmental Conservation, five study streams were selected in Oswego County in the townships of Orwell and Richland (Figure 1). These streams (Orwell Brook, Pekin Brook, Trout Brook, John O'Hara Brook and Sparks Brook) were examined from May through November in 1977. Orwell Brook was studied the most intensively since the number of salmon carcasses along its banks during the spring of 1977 indicated more spawning activity than in the other streams. Its substrate consisted of various-sized stones, i.e., according to the diameter classes of Hynes (1972), gravel (1-2 centimeters), pebbles (3-6 centimeters) and cobbles (6.4-10 centimeters).

Three 100-meter sampling stations were located on Orwell Brook at approximately 2 (Station 3), 3 (Station 2) and 4 (Station 1) kilometers,

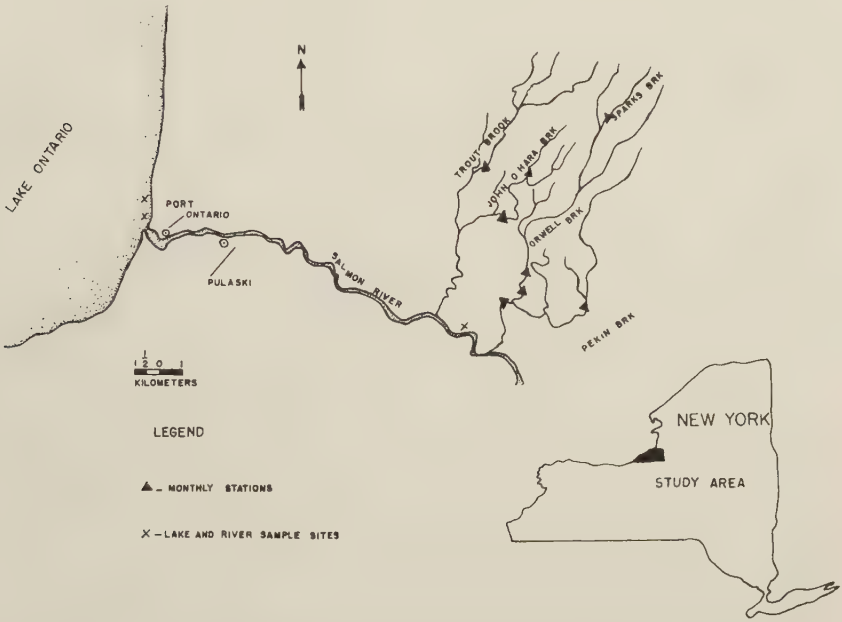

Figure 1. Location of the Salmon River and its tributaries and the stations where collections were made.

respectively, above its confluence with the Salmon River. Temperatures recorded during the study averaged 13° to 21° C. Stream discharge for the upper parts of the brook during August aveaged 0.35 cubic meters per second, while that at Station 3 was substantially higher, averaging 1.24 cubic meters per second, since this station was below the mouth of Pekin Brook (Haggerty, 1977). Haggerty found values of from 8.3 to 8.8 ppm for dissolved oxygen (as O_2) during August 1977. Average specific conductance increased downstream with values of from 54 to 109 umhos, while pH ranged from 7.4 to 7.8.

A single 100-meter station was located on Pekin Brook about 3.5 kilometers above its confluence with Orwell Brook and 6 kilometers from the Salmon River. The substrate in the vicinity of the station consisted mainly of flat rocks up to 24 centimeters in diameter along with gravel, pebbles and cobbles. Maximum and minimum stream temperatures recorded during the study were 22° and 13° C., respectively.

A single 100-meter station was established on Trout Brook 6.5 kilometers from the Salmon River. The substrate there consisted of gravel and pebbles. Trout Brook exhibited the greatest temperature extremes noted, i.e., 15° to 24° C. Its discharge fluctuated greatly throughout the study period with a mean of about 0.47 cubic meter per second (Haggerty, 1977). Haggerty found that specific conductance averaged 84 umhos and 123 umhos at upstream and downstream stations, respectively. Dissolved

oxygen decreased downstream, with values (as O_2) of 9.1 ppm at upstream stations and 8.5 ppm at downstream stations. The pH values averaged 7.7 at both sites.

Two 100-meter stations were located on John O'Hara Brook. A small dam between them probably hindered migrating salmonids except during very high flows and, since low numbers of juveniles were collected at the upper station, records for it are not considered. The lower station was about 2 kilometers above the stream's confluence with Trout Brook and 6 kilometers from the Salmon River. The substrate was complex and varied from flat shale to rounded cobbles and bedrock throughout most of the stream. A temperature range of from 13° to 22° C. was recorded from May to September. Stream discharge varied from 0.40 to 0.59 cubic meter per second at upstream and downstream stations, respectively (Haggerty, 1977). Haggerty found conductivity values of 59 umhos and 79 umhos at two nearby stations. Dissolved oxygen values (as O_2) of 8.8 ppm and 9.5 ppm were recorded at these same stations. The average pH value was 7.5.

A single 100-meter station was located on Sparks Brook 11 kilometers above the Salmon River, but, because few salmonids were caught, collections were terminated after two months.

Juvenile salmonids were collected with a 115-volt A.C. electroshocking unit and a 3-meter minnow seine. A single sweep through each 100-meter stream section (i.e., station) by three people was the standard effort for electroshocking. Seining effort consisted of two people making repeated hauls perpendicular to one bank along the length of the 100-meter section. Station 2 on Orwell Brook was the only one conducive to seining throughout the study period, but seining was done with considerable effort at Station 3 in June.

Overyearling rainbow trout were weighed, measured (total length), fin clipped, scale sampled and released, while subyearling salmonids were only measured and fin clipped prior to release. A different fin clip was used each month. Mark-recapture methods were used to derive population estimates. When the number recaptured was sufficient, the equation of Chapman (Ricker, 1975) was used. When recaptures were few, estimates were made by using catchability coefficients (q) for each group derived from the ratio of recaptured to captured fish as described by J. R. Rychman of the Michigan Department of Natural Resources (personal communication). Recapture operations were carried out within four days of the previous marking operation.

Many coho salmon fry occupied small backwater areas during their first month after hatching, and specimens in these areas were captured with fry traps (Werner, 1968) and dip nets. These populations were isolated from other concentrations of subyearling salmonids and therefore were treated separately, but the same methods were used to obtain population estimates.

Ages of fish were determined from scale impressions in cellulose acetate by use of a Tri-Simplex microprojector. A random sample of 10 rainbow trout per month (May to September) was examined from each stream. During October and November, only specimens from Orwell Brook were examined.

RESULTS

The fish species collected and their occurrence among the five streams are shown in Table 1. Orwell Brook was the only one in which juvenile chinook salmon were collected. A salmonid hybrid (coho salmon X chinook salmon) was also identified from Orwell Brook.

Emergence of coho salmon fry from the gravel began in late May in the Salmon River tributaries. Peak emergence was estimated as June 1 in Orwell Brook, and apparently occurred a few days later in the other streams. Observations on Orwell Brook suggested that coho salmon remain in the vicinity of the redd for a few days but then quickly take up residence in backwater areas (i.e., areas apart from the main stream channel). In Trout Brook and John O'Hara Brook, which lacked backwater areas, coho fry occupied pools. In Orwell Brook, where both pool and backwater habitat was available, they occupied the backwaters. The fry remained in the backwaters for 2 to 3 weeks, after which they occupied pools in the main channel of the stream. When the first population estimate was made

TABLE 1. FISH SPECIES COLLECTED AND THEIR OCCURRENCE AMONG THE STREAMS STUDIED IN THE SALMON RIVER SYSTEM

Species	Orwell Brook	Pekin Brook	Trout Brook	John O'Hara Brook	Sparks Brook
Sea lamprey (*Petromyzon marinus*)	x			x	
American eel (*Anguilla rostrata*)	x		x		
Coho salmon (*Oncorhynchus kisutch*)	x	x	x	x	x
Chinook salmon (*Oncorhynchus tshawytscha*)	x				
Salmonid hybrid (*O. kisutch* × *O. tshawytscha*)	x				
Rainbow trout (*Salmo gairdneri*)	x	x	x	x	x
Brown trout (*Salmo trutta*)	x	x	x	x	x
Brook trout (*Salvelinus fontinalis*)	x	x	x	x	x
Grass pickerel (*Esox americanus vermiculatus*)	x				
Cutlips minnow (*Exoglossum maxillingua*)	x	x	x	x	x
Common shiner (*Notropis cornutus*)	x	x	x	x	x
Blacknose dace (*Rhinichthys atratulus*)	x	x	x	x	x
Longnose dace (*Rhinichthys cataractae*)	x				
Creek chub (*Semotilus atromaculatus*)	x	x	x	x	x
Fallfish (*Semotilus corporalis*)	x		x		
White sucker (*Catostomus commersoni*)	x	x	x	x	
Northern hog sucker (*Hypentelium nigricans*)	x	x	x		x
Brown bullhead (*Ictalurus nebulosus*)	x				
Pumpkinseed (*Lepomis gibbosus*)	x				
Smallmouth bass (*Micropterus dolomieui*)			x		
Fantail darter (*Etheostoma flabellare*)	x	x	x	x	x

at Station 2 in mid-June, substantial numbers were still in the backwaters. The estimated number in six such areas along a 1-kilometer section of Orwell Brook which encompassed Station 2 are given in Table 2. Johnson (1978) suggested that receding stream flows that cut backwater areas off from the main channel during late June may result in high mortality of coho fry occupying these areas by preventing their escape.

The best data are those for Station 2 on Orwell Brook where seining was done monthly from June to October (Table 3). Except in October, the number of coho salmon fry taken there was sufficient for using the Chapman equation to estimate the population. All the other estimates, because of the low numbers collected, were derived by using catchability coefficients. Except for Station 3 on Orwell Brook where data were obtained by seining, estimates were not made for June or July because of the inefficiency of the electroshocker in stunning small salmonids (Table 4). However, by August, the fry of both coho salmon and rainbow trout were large enough to be captured in substantial numbers by this means. The data suggest that juvenile coho salmon were most abundant in Orwell Brook.

Throughout the study, few age 0 chinook salmon were collected although from one to three fry were taken in Orwell Brook each month from June to September. Two age 0 chinook smolts were also collected in the Salmon River near the Pineville bridge in June. In late June and early July, age 0 smolts were collected, along with large numbers of spottail shiners (*Notropis hudsonius*), with a 12-meter bag seine on three con-

Table 2. Population Estimates of Age 0 Coho Salmon in Six Areas Along 1 Kilometer of Orwell Brook on June 15, 1977

Area	Number
1	190 ± 39
2	114 ± 36
3	113 ± 61
4	227 ± 31
5	94 ± 18
6	115 ± 37
Total	853

Table 3. Estimated Numbers of Age 0 Coho Salmon Per 100 Meters of Stream at Stations Studied on Tributaries of the Salmon River During 1977*

Month	Orwell Brook			Pekin Brook	Trout Brook	John O'Hara Brook
	Station 1	Station 2	Station 3			
June	. .	1,722 ± 318	343§	. .	. .	. .
July	. .	894 ± 170	. .	. .	. .	. .
August	. .	138 ± 54	. .	93§	79§	25§
September	125§	72 ± 50	69§	70§	60§	25§
October	. .	48§	. .	. .	. .	. .

*At 95 per cent level of confidence.

§Based on catchability coefficients.

TABLE 4. CATCHABILITY COEFFICIENTS FOR DIFFERENT METHODS USED IN COLLECTING SALMONID FISHES IN TRIBUTARIES OF THE SALMON RIVER, MAY-NOVEMBER 1977

Species	Age	Method	Catchability coefficient (q)
Coho salmon	0	Electroshocker*	0.081
		Seine	0.235
Rainbow trout	0	Electroshocker	0.159
		Seine	0.157
Rainbow trout	I	Electroshocker	0.293

*Although the coefficient for the electroshocker over the entire May-November period was relatively low, after July this equipment did become effective in capturing small coho salmon.

secutive sampling dates in the nearshore area of Lake Ontario 1 kilometer north of the Salmon River estuary. The 15 specimens ranged from 68 to 116 millimeters in total length, with a mean of 89.3 millimeters.

Additional collections of age 0 chinook smolts in Lake Ontario were made during the spring of 1978. In three nights of shore seining 1 kilometer north of the estuary, 14 smolts were collected among schools of silvery minnows (*Hybognathus nuchalis*) and emerald shiners (*Notropis atherinoides*). Six specimens kept for measurement ranged from 57 to 77 millimeters in total length, with a mean of 68.7 millimeters.

Stream residence time for coho salmon during 1976-1977 was apparently less than 1 year since no yearlings were collected in 1977. However, age I smolts were collected in Orwell Brook during the spring of 1978. Stream residence time for juvenile chinook salmon also is evidently less than 1 year in New York.

Variation in fry density between streams was much less for rainbow trout than for coho salmon. The upper and middle stations on Orwell Brook and the one on Trout Brook typically had the highest densities of age 0 rainbow trout, while yearlings were most abundant in Trout Brook (Table 5). The number taken was sufficient to permit using the Chapman equation for making population estimates of age 0 fish in a much larger proportion of the samples for rainbow trout than for coho salmon.

Peak emergence of rainbow trout fry appeared to extend from early June into late July or early August. An increase in the population density in John O'Hara Brook in late summer, for example, was probably the result of continuing emergence. Additional collections in this stream during October revealed numerous small (50-millimeter) rainbow trout fry which may be indicative of late emergence. Recently emerged fry occupied areas with moderate flows for about 10 to 15 days. Thereafter age 0 individuals were in riffles in all of the streams. Throughout the study period, age 0 rainbow trout and coho salmon were spatially segregated in riffles and pools, respectively.

Scale analysis of rainbow trout yielded some interesting between-stream

TABLE 5. ESTIMATED NUMBERS OF RAINBOW TROUT PER 100 METERS OF STREAM AT STATIONS STUDIED ON TRIBUTARIES OF THE SALMON RIVER DURING 1977*

Month	Orwell Brook			Pekin Brook	Trout Brook	John O'Hara Brook
	Station 1	Station 2	Station 3			
	Age 0					
June	. .	287§	. .	. .	. .	. .
July	315 ± 127	480 ± 146	. .	. .	. .	. .
August	. .	. .	. .	35 ± 21	150 ± 120	45§
September	240 ± 166	. .	. .	30 ± 18	83 ± 41	128 ± 113
	Age I					
June	228 ± 155	25§	16§	47 ± 41	165 ± 82	80 ± 55
July	63 ± 32	18 ± 12	19§	32 ± 26	161 ± 96	44 ± 37
August	20 ± 13	. .	. .	31 ± 18	60 ± 20	20 ± 12
September	8 ± 4	16 ± 6	11 ± 6	11 ± 7	61 ± 20	18 ± 14

*At 95 per cent level of confidence.

§Based on catchability coefficients.

comparisons (Table 6). Yearlings in the Orwell Brook-Pekin Brook system were significantly larger each month than those collected from the Trout Brook-John O'Hara Brook system (Table 7). However, this phenomenon was not observed among the age 0 fish. Virtually all rainbow trout left their natal streams before they were 2 years old. Only two age II individuals were collected during the study, and there was no indication of stream-resident fish in the four streams. Limited data suggested that age 0

TABLE 6. AVERAGE TOTAL LENGTH (IN MILLIMETERS) OF JUVENILE ANADROMOUS SALMONIDS IN TRIBUTARIES OF THE SALMON RIVER, BY MONTH IN 1977*

Month	Orwell Brook	Pekin Brook	Trout Brook	John O'Hara Brook
	Coho salmon – age 0			
May	46.7 (20)	. .	. .	. .
June	51.4 (30)	52.0 (4)	. .	. .
July	67.2 (25)	. .	. .	. .
August	71.9 (31)	74.7 (19)	80.5 (13)	86.5 (4)
September	82.3 (33)	77.1 (9)	80.8 (17)	86.5 (4)
October	85.0 (30)	. .	. .	. .
November	93.0 (64)	. .	. .	. .
	Rainbow trout - age 0			
June	27.4 (15)	. .	. .	. .
July	38.9 (20)	. .	. .	. .
August	57.8 (20)	60.3 (17)	62.3 (44)	60.4 (16)
September	59.8 (33)	64.8 (13)	63.4 (47)	63.8 (36)
October	68.7 (26)	. .	. .	. .
November	76.6 (97)	. .	. .	. .
	Rainbow trout - age I			
May	121.8 (10)	120.1 (10)	102.3 (10)	110.2 (10)
July	139.4 (10)	130.2 (10)	113.1 (10)	122.8 (8)
August	139.3 (9)	129.4 (10)	117.0 (10)	123.6 (10)
September	148.2 (10)	129.7 (10)	118.7 (10)	122.1 (10)
October	149.2 (10)	. .	. .	. .
November	152.8 (10)	. .	. .	. .

*Figures in parentheses represent number of fish examined.

TABLE 7. SIGNIFICANCE OF SIZE DIFFERENCES IN YEARLING RAINBOW TROUT FROM THE ORWELL BROOK-PEKIN BROOK SYSTEM AND THOSE FROM THE TROUT BROOK-JOHN O'HARA BROOK SYSTEM, BY MONTH IN 1977*

Month	Degrees of freedom	Value of t	Computed t
May	38	2.025	24.500
July	36	2.029	3.003
August	36	2.029	9.696
September	38	2.025	2.052

*Derived from Student's t test ($P \geq 0.05$).

coho salmon grew faster in the Trout Brook-John O'Hara Brook system than in the Orwell Brook-Pekin Brook system (Table 6).

DISCUSSION

Late-summer population densities of age 0 coho salmon in tributaries of the Salmon River were similar to those observed in five Michigan tributaries of Lake Superior (Stauffer, 1977) and greater than those found in Wisconsin tributaries of Lake Michigan (Avery, 1974). Although Stauffer's data show slightly higher numbers, descriptions of the streams he examined (Peck, 1970; Stauffer, 1977) indicate that they are slightly larger than the Salmon River tributaries. Johnson (1978), however, found that production of age 0 coho salmon in Orwell Brook from July through October was higher than that reported in the Michigan streams by Stauffer (1975).

Limited evidence suggests that in the Salmon River system chinook salmon may emerge first and undergo smoltification earlier than coho salmon. In the Salmon River tributaries, peak spawning of chinook salmon occurs 3 to 4 weeks prior to that of the coho. In a British Columbia stream, Lister and Genoe (1970) found the fry of earlier-spawning chinook salmon to emerge 4 to 6 weeks before those of the coho. However, when the peak spawning periods of the two species overlap, peak emergence has been reported to occur earlier for the coho than for the chinook (Stein et al., 1972). The presence of chinook salmon smolts in Orwell Brook as early as June suggests that chinook fry did emerge earlier than coho fry.

A possible explanation for the presence of age 0 chinook smolts in Lake Ontario as early as May is successful spawning in the Salmon River. Adult chinook salmon have been observed constructing redds in the Salmon River during the fall (Thomas Eckert, N.Y.S. Department of Environmental Conservation, personal communication). Stein et al. (1972) found that chinook fry were more abundant in a main river than coho fry, which were more abundant in the tributaries. Also, they observed that most chinook salmon reside only 3 months in fresh water.

The large size and tremendous fluctuations in its discharge due to hydroelectric power demands make the Salmon River a very difficult system to study. These fluctuations could result in fry leaving the river ear-

ly. Collection of chinook smolts during limited sampling in the Salmon River itself and in close proximity to its confluence with Lake Ontario indicates that the river may be producing substantial numbers of this species.

Numbers of rainbow trout in the tributaries of the Salmon River were similar to those found in Wisconsin (Niemuth, 1970) but less than were observed in Minnesota (Hassinger et al., 1974) and Michigan (Stauffer, 1977; Taube, 1975). However, since the streams studied in the latter two states were larger than the Salmon River tributaries, the densities of fry were similar.

The duration of stream residency of juvenile rainbow trout in the Salmon River system may be less than 2 years. Migration of age II fish, however, could have occurred before sampling was begun during mid-May in 1977. Scale analysis revealed only two age II parr. The apparently early migration of age 0 and age I rainbow trout is characteristic of other Great Lakes spawning populations since various authors have reported the migration of this species at age II or less in tributaries through the region (Greeley, 1933; Dodge and MacCrimmon, 1970; Niemuth, 1970; Kwain, 1971; Stauffer, 1972; Hasinger et al., 1974).

There is no generally accepted explanation for the early migration of rainbow trout smolts in these waters. Hassinger et al. (1974) theorized that the emigration of age 0 fish from Minnesota streams may result from competition from native brook trout (*Salvelinus fontinalis*) and other species. This is a plausible explanation for streams in the Salmon River system; certainly the potential exists for competition with four other salmonid species, as well as other members of the fish community.

Although no quantitative data were collected regarding habitat segregation, observations throughout the study suggested that the fry of coho salmon and rainbow trout were spatially separated. Those of the salmon occupied relatively slow-flowing pools, whereas those of the trout occupied riffles within 2 to 3 weeks of emergence. These findings agree with those of Hartman (1965) and Allee (1974) with respect to these species when in the same streams.

The growth of age 0 coho salmon and juvenile rainbow trout in New York is comparable to that observed in Michigan (Stauffer, 1972, 1977; Wager, 1975) and Minnesota (Hassinger et al., 1974) but slower than that is Wisconsin (Avery, 1974). However, different collection methods were used in these studies and resulted in different efficiencies in capturing fish of various sizes. Also, in Wisconsin where the growth rate was fastest, the densities of anadromous salmonids were lowest. The significantly faster growth of age I rainbow trout in the Orwell Brook-Pekin Brook system may have resulted from extensive feeding on salmon eggs (Johnson, 1978; Johnson and Ringler, 1979).

The possible importance of salmon eggs in the growth of juvenile rainbow trout is best illustrated by the data for age 0 fish in the stream studied

(Table 6). In September, these fish were of about the same size in all four streams. However, there were size differences between the streams for age I fish in May, indicating a growth differential during the fall and winter. The time from September to May is a period of relatively slow growth for most fishes. The authors suspect that the presence of salmon eggs in the fall may have been a major reason for the faster growth of juvenile rainbow trout in the Orwell Brook-Pekin Brook system.

LITERATURE CITED

ALLEE, B. J. 1974. Spatial requirements and behavioral interactions of juvenile coho salmon (*Oncorhynchus kisutch*) and steelhead trout (*Salmo gairdneri*). Ph.D. thesis, Univ. Washington Library.

AVERY, E. L. 1974. Reproduction and recruitment of anadromous salmonids in Wisconsin tributaries of Lake Michigan. Wis. Dept. Nat. Resources.

DODGE, D. P., AND H. R. MACCRIMMON. 1970. Vital statistics of a population of Great Lakes rainbow trout (*Salmo gairdneri*) characterized by an extended spawning season. Jour. Fish. Res. Bd. Canada 27:613-618.

GREELEY, J. R. 1933. The growth rate of rainbow trout from some Michigan waters. Trans. Am. Fish. Soc. 63:361-378.

GREENE, C. W. 1940. Stocking policy for the Ontario watershed with suggestions for other fish management methods. In: A Biological Survey of the Lake Ontario Watershed: 20-41. N.Y.S. Cons. Dept.

HAGGERTY, G. 1977. Salmon Rivers cooperative conservation advisory council stream study. (Prepared by Salmon Rivers Cooperative Advisory Council, Parish, N.Y.; published by Temporary State Commission on Tug Hill, 317 Washington St., Watertown, N.Y.)

HARTMAN, G. F. 1965. The role of behavior in the ecology and interaction of underyearling coho salmon (*Oncorhynchus kisutch*) and steelhead trout (*Salmo gairdneri*). Jour. Fish. Res. Bd. Canada 22:1035-1081.

HASSINGER, R. L., J. G. HALE AND D. E. WOODS. 1974. Steelhead of the Minnesota north shore. Minn. Dept. Nat. Resources, Tech. Bull. 11.

HYNES, H. B. N. 1972. The Ecology of Running Waters. Univ. Toronto Press., Toronto.

JOHNSON, J. H. 1978. Natural reproduction and juvenile ecology of Pacific salmon and steelhead trout in tributaries of the Salmon River, New York. M.S. thesis, State Univ. New York, College Environ. Sci. and Forestry at Syracuse.

JOHNSON, J. H., AND N. H. RINGLER. 1979. Predation on Pacific salmon eggs by salmonids in a tributary of Lake Ontario. Jour. Great Lakes Res. 5:177-181.

KWAIN, W. 1971. Life history of rainbow trout (*Salmo gairdneri*) in Batchawana Bay, eastern Lake Superior. Jour. Fish. Res. Bd. Canada 28:771-775.

LEAF, A. L., AND R. L. WITTWER. 1974. Soils and geology. In: Resources of the Tug Hill Region: 7-35. State Univ. New York, College Environ. Sci. and Forestry.

LISTER, D. B., AND H. S. GEONE. 1970. Stream habitat utilization by cohabiting underyearlings of chinook (*Oncorhychus tshawytscha*) and coho (*O. kisutch*) in the Big Qualicum River, British Columbia. Jour. Fish. Res. Bd. Canada 27:1215-1224.

MACCRIMMON, H. R., AND B. L. GOTS. 1972. Rainbow trout in the Great Lakes. Ontario Min. Nat. Resources.

NIEMUTH, W. 1970. A study of migratory lake run trout in the Brule River, Wisconsin: Part II—rainbow trout. Wis. Dept. Nat. Resources, Fish. Mgt. Rept. 38.

PARSONS, J. W. 1973. History of salmon in the Great Lakes, 1850-1970. U.S. Fish and Wildl. Serv., Tech. Paper 68.

PECK, J. W. 1970. Straying and reproduction of coho salmon, *Oncorhynchus kisutch*, planted in a Lake Superior tributary. Trans. Am. Fish. Soc. 99:591-594.

RICKER, W. E. 1975. Computation and interpretation of biological statistics of fish populations. Fish. Res. Bd. Canada, Bull. 191.

Scott, W. B., and E. J. Crossman. 1973. Freshwater fishes of Canada. Fish. Res. Bd. Canada, Bull. 184.

Stauffer, T. M. 1972. Age, growth, and downstream migration of juvenile rainbow trout in a Lake Michigan tributary. Trans. Am. Fish. Soc. 101:18-28.

_____ 1975. Population characteristics and summer-to-autumn survival of juvenile rainbow trout and coho salmon in two Lake Superior tributaries, 1969-1972. Mich. Dept. Nat. Resources, Fish. Res. Rept. 1825.

_____ 1977. Numbers of juvenile salmonids produced in five Lake Superior tributaries and the effect of juvenile coho salmon on their numbers and growth, 1967-1974. Mich. Dept. Nat. Resources, Fish. Res. Rept. 1846.

Stein, R. A., P. E. Reimers and J. D. Hall. 1972. Social interaction between juvenile coho (*Oncorhychus kisutch*) and fall chinook salmon (*O. tshawytscha*) in Sixes River, Oregon. Jour. Fish. Res. Bd. Canada 29:1737-1748.

Taube, C. M. 1975. Abundance, growth, biomass, and interrelationship of trout and coho salmon in the Platte River. Mich. Dept. Nat. Resources, Fish. Res. Rept. 1830.

Wagner, W. C. 1975. Food habits of coexisting juvenile coho salmon, brown trout and rainbow trout in the Platte River, 1967 and 1972. Mich. Dept. Nat. Resources, Fish. Res. Rept. 1831.

Werner, R. G. 1968. Methods of sampling larvae in nature. In: Methods of Assessment of Fish Production in Freshwaters (W. E. Ricker, Ed.): 179-181. Blackwell Sci. Publ., Oxford, England.

OVERWINTER WEIGHT LOSS IN WHITE-TAILED DEER IN NEW YORK

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ABSTRACT

White-tailed deer annually lose weight during the fall and winter and gain weight during the summer. The loss begins in late October or early November, varying with the sex and age of the animal. Fall weights differ greatly between populations that exceed the carrying capacity of their range and those that do not. The weight-of-no-return and its relation to weight at time of death from starvation are discussed. Regression equations for weight loss are given.

White-tailed deer (*Odocoileus virginianus*) annually lose weight during the fall and winter and gain weight during the summer. When the loss begins, what proportion of the fall weight is lost and how this is affected by the relationship of the deer population to the carrying capacity of its range are of interest to the wildlife manager. This paper summarizes information on overwinter weight loss that has been recorded during studies of deer in New York.

METHODS

Weight records for deer during the fall and winter, principally between the early 1930's and the mid-1950's, were compiled for central New York, the Southern Tier and the central Adirondacks. Data for the fall were chiefly dressed weights of deer taken by hunters[2], whereas winter records were mainly round weights for deer killed by motor vehicles or that died of starvation. For analysis, dressed weights were converted to round weights by the equation of Severinghaus (1949b), i.e., round weight = (dressed weight + 1.5) × 1.269. Fall was considered to be the period of October, November and December, and winter that of January, February and March. Age was determined according to Severinghaus (1949a), except that prior to the adoption of this technique the only distinction was between fawns and older deer.

Records for deer that died from starvation were very largely obtained during dead-deer surveys in late winter and early spring. They were noted as to whether the carcass was found in a sheltered area or on an exposed slope. In the center Adirondacks all the records were from sheltered areas. However, in central New York and the Southern Tier a large proportion were from exposed slopes, especially those facing south where the snow disappears first and deer congregate as a result.

[1]Retired.

[2]These records were gathered under New York Federal Aid in Fish and Wildlife Restoration Projects 1-R-Supp. C, W-28-R and W-89-R and were also discussed by Severinghaus (1979).

RESULTS

Mortality among fawns is of particular importance in the life equation of deer. The data for fawns in the central Adirondacks, the poorest range in the State, are summarized in Table 1. The fall weights were taken in

Table 1. Weights of Fawn Deer in the Central Adirondacks During the Fall and Winter, As Well As At the Time of Death From Starvation

Time	Number	Weight (pounds)*			
		Minimum	Maximum	Mean	Standard deviation
Male					
Fall	186	50.1	97.1	69.9	12.2
Winter	22	40.0	80.0	54.2	11.7
At death from starvation	42	30.0	70.0	45.7	8.6
Female					
Fall	175	40.0	98.4	67.0	12.7
Winter	17	25.0	70.0	52.5	11.9
At death from starvation	42	33.0	63.0	41.8	8.5

*Data in round weight; those for fall period converted from dressed weight.

October and November, and the winter weights during January, February and March. Using November 1 and February 14 as the median dates, respectively, there was a 15-week interval. During this period, for animals that died of causes other than starvation, the mean weight of male fawns dropped 15.7 pounds or 22.5 per cent of their fall weight, while for females the corresponding figures were 14.5 pounds and 21.6 per cent. The regression equations were

$$\text{for males} \quad W = 69.9 - 1.0493X$$
$$\text{for females} \quad W = 67.0 - 0.9647X$$

where:

W = winter weight in pounds
X = number of weeks

For animals that died from starvation, mean weight dropped an additional 8.5 pounds for male fawns and 10.7 pounds for females. Thus, the average "weight-of-no-return" must have been between the mean winter live weight and the mean starvation-death weight, i.e., between 54.2 and 45.7 pounds for males and between 52.5 and 41.8 pounds for females. Compared with fall weight, this would represent losses in excess of some 30 per cent. Variations among individuals should be approximated by the standard deviations shown in Table 1. According to the t test (Snedecor, 1956), winter live weights were significantly different from fall weights for both male and female fawns, and starvation-death weights were significantly different from winter live weights (Table 2).

Records for specific dates during the fall were available for hunter-killed deer. Those for yearling males in the central Adirondacks in 1954 when

TABLE 2. SIGNIFICANCE OF VARIOUS WEIGHT COMPARISONS (AS GIVEN IN TABLES 2 AND 4) FOR FAWN DEER IN NEW YORK*

Comparison	Degrees of freedom	Value of t
Male		
Central Adirondacks		
Fall weight vs. winter live weight	206	5.75§§
Winter live weight vs. starvation-death weight	62	3.32§
Central New York and Southern Tier		
Fall weight vs. winter live weight	178	9.98§§
Winter live weight vs. starvation-death weight for exposed slope	70	6.70§§
Starvation-death weight: exposed slope vs. sheltered area	38	3.04§
Female		
Central Adirondacks		
Fall weight vs. winter live weight	190	4.71§§
Winter live weight vs. starvation-death weight	57	3.89§§
Central New York and Southern Tier		
Fall weight vs. winter live weight	182	11.40§§
Winter live weight vs. starvation-death weight for exposed slope	98	8.84§§
Starvation-death weight: exposed slope vs. sheltered area	39	3.39§§

*According to t test (Snedecor, 1956).

§Significant at $P < 0.005$.

§§Significant at $P < 0.001$.

deer with antlers less than 3 inches long could be taken legally are summarized in Table 3. The average weight of the 154 animals examined was 107.1 pounds. Considering only those with antlers 3 inches or more in length, the average was 111.5 pounds. For all the records, the mean weight dropped 11.0 pounds or 9.6 per cent from October 25 to November 14. The regression equation was

$$W = 84.44 - 0.2046X$$

where:

W = weight on November 14
X = number of days from October 25 to day taken

When this loss was tested for significance, the t value (2.01, with 34 degrees of freedom) fell just short of being significant (i.e., 2.03 at the 95 per cent level of confidence).

Deer range in central New York and the Southern Tier is of higher quality than that in the central Adirondacks. The data for fawns in this area are summarized in Table 4. The fall weights were taken in late November and the winter weights during January, February and March. Using November 22 and February 14 as the median dates, respectively, there was a 12-week interval. During this period, for animals that died of causes other than starvation, the mean weight of male fawns dropped 20.5

Table 3. Weights of Yearling Male Deer in the Central Adirondacks During the Fall in 1954

Time	Number	Weight (pounds)*			
		Minimum	Maximum	Mean	Standard deviation
October 25	18	93.3	121.3	115.0	18.3
October 26	24	85.7	133.9	106.4	15.2
October 27-29	22	84.4	147.8	106.8	18.7
October 20-November 2	23	75.5	126.3	104.1	15.3
November 3-6	21	78.0	141.5	108.1	17.3
November 7-10	28	67.9	126.3	106.3	15.5
November 11-14	18	85.7	145.3	104.0	18.3
Total	154	67.9	147.8	107.1	16.9

*Data in round weight, converted from dressed weight.

Table 4. Weights of Fawn Deer in Central New York and the Southern Tier During the Fall and Winter, As Well As At the Time of Death From Starvation

Time	Number	Weight (pounds)*			
		Minimum	Maximum	Mean	Standard deviation
Male					
Fall	129	69.2	122.5	95.9	12.3
Winter	51	50.0	105.0	75.4	12.9
At death from starvation					
Sheltered area	9	35.0	55.0	46.2	5.7
Exposed slope	21	40.0	76.0	55.1	7.9
Female					
Fall	124	66.6	136.4	91.0	13.3
Winter	60	50.0	95.0	68.7	10.4
At death from starvation					
Sheltered area	6	37.0	45.0	40.7	4.8
Exposed slope	35	38.0	70.0	51.1	7.2

*Data in round weight; those for fall period converted from dressed weight.

pounds or 21.4 per cent of their fall weight, while for females the corresponding figures were 22.3 pounds and 24.5 per cent. The regression equations were

$$\text{for males} \quad W = 95.9 - 1.7108X$$
$$\text{for females} \quad W = 91.0 - 1.8600X$$

For animals that died from starvation, the loss from fall weight varied greatly depending on whether the deer had been in sheltered winter range or on an exposed slope. Male fawns found in sheltered areas had lost an average of 49.7 pounds or 51.8 per cent of their fall weight, whereas for those found on exposed slopes the corresponding figures were 40.8 pounds and 42.5 per cent. For female fawns these values were 50.3 pounds (55.3 per cent) for sheltered areas compared with 39.9 pounds (43.8 per cent) for exposed slopes. For males the average weight-of-no-return would have been between the mean winter live weight of 75.4 pounds and the mean starvation-death weight of 46.2 pounds for sheltered areas and 55.1 pounds for exposed slopes. For females, it would have been between 68.7

pounds and 40.7-51.1 pounds. Compared with fall weight, this would represent losses in excess of some 40 per cent. The significance of the comparisons is also given in Table 2.

Apparently, animals in sheltered habitat were able to withstand a greater loss of weight before succumbing than were those in exposed situations. Although the samples for sheltered areas in central New York and the Southern Tier were small, the mean weights at death from starvation for both male and female fawns were not significantly different from the corresponding weights for sheltered range in the central Adirondacks (Tables 1 and 4).

For adult deer, the records for the central Adirondacks are summarized in Table 5. Only animals 7½ years old or older are included because

TABLE 5. WEIGHTS OF ADULT DEER IN THE CENTRAL ADIRONDACKS DURING THE FALL AND WINTER, AS WELL AS AT THE TIME OF DEATH FROM STARVATION*

Time	Number	Weight (pounds)§			
		Minimum	Maximum	Mean	Standard deviation
		Male			
Fall	51	121.2	282.4	205.3	35.3
At death from starvation	16	65.0	132.0	101.9	21.4
		Female			
Fall	81	89.5	177.0	120.5	17.4
At death from starvation	12	65.0	96.0	75.9	14.4

*Includes only animals 7½ years old or older.

§Data in round weight; those for fall period converted from dressed weight.

younger adults were rarely found dead from starvation in this region. Fall weights represent October-November, and starvation deaths represent February-March. The sample for the winter period was not sufficient for analysis because it was scattered widely among age groups. The males found dead had lost an average of 103.4 pounds (50.4 per cent) compared with the mean weight for the fall. For the females these values were 44.6 pounds and 37.0 per cent. The lack of winter data also precluded estimating a weight-of-no-return.

The records for adult deer in central New York and the Southern Tier are summarized in Table 6. In this case, all deer 1½ years old or older are included because adults found dead from starvation were not limited to old individuals. Fall weights represent November, and starvation deaths represent February-March. Records for the winter period were insufficient in this region also. No adult males were found dead. The females that died had lost an average of 44.6 pounds (30.0 per cent) compared with the mean weight for the fall. In this region, where the dead deer were found very largely on exposed slopes, the females that died from starvation succumbed before their weight (mean of 103.9 pounds) had dropped as low as

Table 6. Weights of Adult Deer in Central New York and the Southern Tier During the Fall and Winter, As Well As At the Time of Death From Starvation*

Time	Number	Weight (pounds)§			
		Minimum	Maximum	Mean	Standard deviation
Male					
Fall	143	141.5	306.5	202.7	37.1
At death from starvation	0	. .	. .	. .	. .
Female					
Fall	140	111.0	199.9	148.5	16.9
At death from starvation	13	68.0	130.0	103.9	19.9

*Includes all animals 1½ years old or older.

§Data in round weight; those for fall period converted from dressed weight.

that (75.9 pounds) of their counterparts in the central Adirondacks where dead deer were found chiefly in sheltered areas.

DISCUSSION

Davenport (1939) studied weight loss among white-tailed deer during the winter and concluded that "healthy animals (deer) in good condition can safely lose 30 per cent of their weight and some are able to lose considerably more and still survive". Weight decline from early November through December was described by White (1968) who showed differences in loss between the sexes and between age groups. He also found that variations in weight between years result from differences in "growing period" and that "a particularly fine growing season might produce fawns this year which are considerably larger and heavier than usual". White pointed out that "annual variations in fawn weight are seemingly caused by varying abundance and quality of food during summer and fall" and that "the duration of snow cover prior to the time of kill" results in fawns "lighter in weight than during those years when bare ground occurs".

The data presented here show that fall weights for deer in the central Adirondacks where populations tend to exceed the winter carrying capacity differ significantly from those for deer in central New York and the Southern Tier where populations seldom exceed the carrying capacity. Male fawns on the latter range averaged 25 pounds heavier. There was a similar difference for winter weights, male fawns averaging 21 pounds, and female fawns 16 pounds, heavier on the better range.

The weight loss that a deer can tolerate and still survive depends on its fall weight. For fawns, the data indicate that this proportion would be about 30 per cent of the fall weight in the central Adirondacks and about 40 per cent in central New York and the Southern Tier. At the same time, the actual weight at which a fawn would die from starvation is greatly influenced by shelter quality. On range where shelter conditions (coniferous habitat and protective topography) were good to excellent, the starvation-

death weights were virtually the same in both regions of the State, averaging about 46 pounds for male fawns and 41 pounds for female fawns. However, on exposed slopes where there was little or no good shelter, fawns died before their weight had dropped that low (55.1 pounds for males and 51.1 pounds for females), a differential of some 20 per cent or more. The data also indicate that shelter is as important to the survival of adult deer as it is to that of fawns.

That the starvation-death weights for fawns were similar in both regions where winter shelter conditions were comparable is evidence that the weight-of-no-return is at least that low. Furthermore, the substantially higher average winter live weight of fawns in central New York and the Southern Tier represents a greater potential for survival and is probably correlated with the usually shorter winters, lesser average snow depths and lower winter concentrations of deer on the southern range.

In order for fawns to attain their growth potential between birth and their first fall, a deer population must not exceed the carrying capacity of the range it occupies. Data on the fall weight of fawns can be an index of this relationship. To be comparable, weights taken after late October should be adjusted for the overwinter loss that occurs.

LITERATURE CITED

DAVENPORT, LAVERN S. 1939. Results of deer feeding experiments at Cusino, Michigan. Trans. 4th N.A. Wildl. Conf.:268-274.

SEVERINGHAUS, C. W. 1949a. Tooth development and wear as criteria of age in white-tailed deer. Jour. Wildl. Mgt. 13(2):195-216.

_____ 1949b. The live weight-dressed weight and live weight-edible meat relationship in deer. N.Y.S. Conservationist 4(2):26.

_____ 1979. Weights of white-tailed deer in relation to range conditions in New York. N.Y. Fish and Game Jour. 26(2):162-187.

SNEDECOR, G. W. 1956. Statistical Methods. Iowa State College Press, Ames, Iowa.

WHITE, DAVID L. 1968. Condition and productivity of New Hampshire deer. In: The White-tailed Deer of New Hampshire (H. R. Seigler, Ed.). Survey Rept. 10, New Hampshire Fish and Game Dept.

DECLINE OF THE WALLEYE POPULATION IN BLACK LAKE

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ABSTRACT

Black Lake has historically supported a prime walleye fishery. The population and fishery reportedly began to decline in the late 1960's. In 1975, information on the age structure among males, the abundance of fingerlings and the relative abundance of adults was collected. No walleye fingerlings were taken in trawls, and adult walleyes comprised only 1 per cent of the total gillnet catch over the 6-month sampling period. Analysis of the age composition of spawning males indicated that there had been no recruitment since 1971 and that recruitment in 1970 and 1971 had been low. The introduction of the black crappie in the early 1960's may have been associated with the walleye decline.

Black Lake, 3,340 hectares (8,350 acres), is located in southwestern St. Lawrence County in northern New York. It is a shallow, eutrophic lake and has an average depth of about 2.5 meters (8 feet) with a maximum of 5 meters (16 feet). Mid-summer pH is 9.5 and total alkalinity is 48 milligrams per liter (48 ppm). The lake supports a prime warmwater fishery and, historically, the major gamefish has been the walleye (*Stizostedion vitreum vitreum*). The walleye population has been maintained by natural spawning in the lake's two major tributaries and possibly in smaller streams and on lake shoals. Stocking has been limited to plantings of fingerlings in 1961 and 1962, and of fry in 1969, 1971, 1973 and 1976.

Several fishery surveys and studies were made by the State Conservation Department (presently the Department of Environmental Conservation). The fish community was sampled in a cursory manner in 1950 and 1963, with the walleye, due to its importance to the sportfishery, being studied most intensively. A preliminary tagging study was carried out in 1953, followed by a more detailed investigation from 1961 to 1964 designed to provide information on growth rates, population size, spawning success and angler harvest. LeTendre and Schneider (1969) reported on the part of the latter study concerning age and growth of male walleyes collected during the spawning runs. In general, they found a stable, healthy population to have been present at that time.

Subsequently, at the request of local businessmen and sportsmen who reported a declining walleye fishery, a similar study was made in 1970 and 1971, but the results were inconclusive. Also, to evaluate the contribution of stocked walleye fry to the total fry population, fry were stocked in alternate years from 1969 to 1973, but low densities were found in both cases (Forney, 1975). The results of the fry study together with continued reports of poor walleye fishing led to the present study which was carried out in 1975 to provide information on the age structure of the male spawning population, to evaluate the abundance of walleye fingerlings and to determine the relative abundance of adults during the summer.

METHODS AND MATERIALS

During the spawning period, walleyes from Black Lake enter the Indian River and concentrate at a barrier in the village of Rossie. Walleyes were collected from the spawning area by blind scapping with long-handled dip nets in 1975 on the nights of April 2, 4 and 7. Samples of walleyes had been collected from the same site in 1953, from 1961 to 1964 and in 1970 and 1971. To evaluate the fingerling population, five standard trawl sites were established in the main lake basin and sampled monthly from May to October with a 5.9-meter (18-foot) otter trawl. Each month one 5-minute haul was made at each site at an approximate tow speed of 5 kilometers per hour (3 miles per hour). The relative abundance of adults was determined by sampling with gillnets monthly from May to October, except August. Each month three or four gillnets of experimental design were set overnight at randomly selected sites. The nets were 45 meters (150 feet) long by 1.5 meters (5 feet) deep and consisted of six 8-meter (25-foot) panels of bar mesh in the following sizes: 19, 25, 30, 32, 38 and 45 millimeters (0.75, 1.0, 1.2, 1.25, 1.5 and 1.75 inches).

Walleyes collected were measured to the nearest millimeter in total length, and a scale sample was taken from below the lateral line posterior to the tip of the pectoral fin. Sex was determined by partial stripping or internal examination. Scale impressions were made on cellulose acetate slides, and age determinations were made using a Kodak Easamatic 40-microfiche reader. Annuli were identified by the characteristics described by Carlander and Whitney (1961).

RESULTS AND DISCUSSION

A total of 95 walleyes, 61 males and 34 females, were collected from the Indian River at Rossie during the spawning run in 1975. Four of the males had been tagged at Rossie during prior studies, one in 1961 and three in 1971. Age determination was difficult because annuli were closely crowded on the scale margin. However, validity of the aging technique was supported by scale samples from the fish that were recaptured, age-length information from 1961 to 1964 (LeTendre and Schneider, 1969) and tag return data. It is assumed that the age composition of the sample was representative of the spawning run in 1975.

The age composition of males collected in 1975 is compared with that reported for spawning males from 1961 to 1964 by LeTendre and Schneider (1969) and in 1970 (N.Y.S. Conservation Department, unpublished) in Table 1. Age groups III to V, which comprised 54 per cent of the collections from 1961 to 1964 and 33 per cent of that in 1970, were not present in 1975. The absence of these age groups corresponded with the low to undetectable densities of walleye fry reported for the period from 1969 to 1973 by Forney (1975). It is also interesting that no walleyes older

Table 1. Distribution of Age Groups Among Male Walleyes Collected From Black Lake in 1961-1964, 1970 and 1975

Year	Number	Age group											
		III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV
1961	175	36	32	26	41	35	4	1	. .	. .	. .	. .	. .
1962	190	39	21	24	38	43	17	8	. .	. .	. .	. .	. .
1963	175	38	50	22	21	20	22	2	. .	. .	. .	. .	. .
1964	171	14	38	45	20	20	27	7	. .	. .	. .	. .	. .
1970	76	. .	5	20	27	13	6	5	. .	. .	. .	. .	. .
1975	60	. .	. .	. .	3	5	9	13	6	13	7	3	1

Table 2. Mean Total Length For Spawning Male Walleyes From Black Lake Collected in 1953, 1961-1964, 1970-1971 and 1975

Year	Number	Total length (millimeters)		
		Mean	Standard deviation	Range
1953	115	414	39.9	302-503
1961	298	391	36.1	292-488
1962	361	406	35.3	307-513
1963	116	371	42.9	393-465
1964	241	386	32.8	297-470
1970	591	419	29.7	305-541
1971	237	432	26.4	345-508
1975	61	481	24.0	434-536

than age IX were reported from 1961 to 1964 or in 1970, while in 1975 fish of ages X to XIV made up 50 per cent of the sample.

Mean length, standard deviation and size range for the males collected in 1975 are summarized and compared with the corresponding values from previous collections in Table 2. The mean in 1976 was significantly larger and the standard deviation smaller in comparison with values for the other years. The absence of the younger age groups is further evident when the length-frequency distribution for 1976 is compared with those for 1963, 1970 and 1971 (Figure 1).

LeTendre and Schneider (1969) concluded that, in Black Lake, male walleyes are typically recruited to the spawning population at age III and an average size of 328 millimeters (12.9 inches). Further interpretation of Table 2 and Figure 1 appears to indicate that recruitment of 3-year-old male walleyes was low in 1970 as shown by an increase in the mean size and a significant decrease in the relative abundance of fish 280 to 350 millimeters (11 to 13 inches) long as compared with data from 1963 when a strong year class of 3 year olds was recruited. Using the same criteria, there was apparently little or no recruitment of age III males in 1971.

No fingerling walleyes were captured in trawls, although the trawl used in Black Lake was identical to one used successfully to estimate the abundance of fingerling walleyes in Oneida Lake as described by Forney (1978). Assuming fingerling distribution and vulnerability to capture by trawling

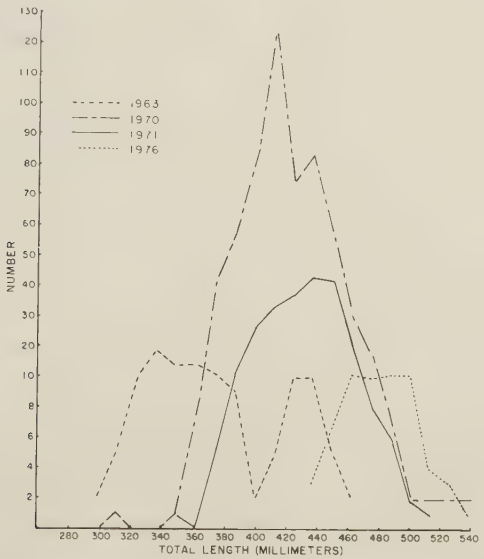

Figure 1. Length-frequency distribution of male walleyes collected in Black Lake in 1963 1970, 1971 and 1976.

in Black Lake to have been similar to that in Oneida Lake, fingerling production in Black Lake was negligible in 1975.

The maximum age of walleyes observed in samples increased from IX in 1961-1964 and 1970 to XIV in 1975 which suggests increased survival of older fish (Table 1). Expansion of the crappie population may have reduced fishing pressure on walleyes, and the vulnerability of walleyes to angling may have declined. LeTendre and Schneider (1969) detected an inverse relationship between vulnerability and growth. Mean lengths of age VI to IX walleyes were greater in 1975 than in earlier years (Table 3). However, more rapid growth may have facilitated detection of annuli, and the ages of some specimens in the 1961 to 1970 samples may have been underestimated.

The existing data base is insufficient to identify the cause or causes of the decline of the walleye population from a stable, viable condition in the

TABLE 3. MEAN TOTAL LENGTH (IN MILLIMETERS) BY AGE GROUP FOR MALE WALLEYES COLLECTED IN BLACK LAKE IN 1961-1964, 1970 AND 1975

Year	Age group										
	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII
1961-1964*	328	363	389	411	424	439	442	. .	. .	. .	. .
1970	. .	376	394	414	434	450	460	. .	. .	. .	. .
1975§	. .	. .	. .	438	461	462	472	485	489	511	534

*Unweighted means of calculated mean lengths at successive ages for male walleyes from 1953 to 1961 year classes as given by LeTendre and Schneider (1969).

§Data from tagged fish that were recaptured not included.

1950's and early 1960's to a remnant level in 1975. It is known that black crappie (*Pomoxis nigromaculatus*) were introduced and became established between 1953 and 1962. In 1975, they comprised 24 per cent of the total trawl catch and were estimated, along with yellow perch (*Perca flavescens*), to be the most abundant species present. The predatory habits of crappie have been summarized by Ming (1971), but little is known specifically about walleye-crappie interrelationships. It is likely that the establishment of the black crappie population was involved in the decline of the walleye, but the unknown effects of angler harvest and environmental changes must also be considered.

LITERATURE CITED

Carlander, K. D., and R. R. Whitney. 1961. Age and growth of walleyes in Clear Lake, Iowa, 1935-1937. Trans. Am Fish. Soc. 90(2):130-138.

Forney, J. L. 1975. Contribution of stocked walleye fry to walleye fry populations in New York lakes. Prog. Fish-Cult. 29(1):20-24.

_____ 1978. Dynamics of a walleye-yellow perch predator-prey association in Oneida Lake. New York Federal Aid in Fish and Wildlife Restoration Project F-17-R (final report for Job I-a). N.Y.S. Cons. Dept. (mimeo.)

LeTendre, G. C., and C. P. Schneider. 1969. Age and growth of male walleyes in spawning runs from Black Lake, New York. N.Y. Fish and Game Jour. 16(2):136-144.

Ming, A. 1971. A review of the literature on crappies in small impoundments. Missouri Federal Aid in Fish and Wildlife Restoration Project F-1-R, Study I (final report for Job 1). Missouri Dept. Cons. (mimeo.)

ATTITUDES OF RESIDENTS IN THE PERIPHERAL ADIRONDACKS TOWARD ILLEGALLY KILLING DEER

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ABSTRACT

Questionnaire-interview surveys of residents in the peripheral Adirondacks indicated that illegal killing of deer was generally recognized as an important factor holding the deer population there below the carrying capacity of the range. While the local people indicated they would not tolerate such killing for wanton or commercial purposes, they were more tolerant if it was for food or by accident.

Wildlife biologists and conservation law enforcement officers have recognized for over four decades that the population of white-tailed deer (*Odocoileus virginianus*) in the peripheral Adirondacks of northern New York (Figure 1) has been static at a level well below the carrying capacity of the range. Illegal hunting throughout the year was cited by Darrow (1948) and Severinghaus and Brown (1956) as the controlling factor in this region. Severinghaus and Free (1963) discussed the situation in more detail and pointed out that the legal take of deer, limited almost exclusively to bucks[1], would not account for the lack of increase. They concluded that significant increases in deer abundance would be possible if losses among does were reduced substantially. Severinghaus (1967) presented evidence that, where losses from other causes remain at low to moderate levels and legal hunting is limited primarily to bucks, deer populations will grow.

Recognizing the potential for substantially increasing deer abundance in the peripheral Adirondack region, as well as associated consumptive and non-consumptive recreational opportunities, the Bureau of Game of the State Conservation Department, in collaboration with the Bureau of Law Enforcement, began a study in 1968 in the Town of Malone in Franklin County, which was considered a representative area (Jackson, 1969a). The objective was to demonstrate an increase in the deer population if removal

[1]Since 1912, legal deer hunting in New York during the general open season has been limited to the taking of bucks with antlers at least 3 inches long, except that in 1919 hunting for deer of either sex (except fawns) was permitted. However, in recent years various provisions for taking antlerless deer or deer of either sex under special regulations have been employed to meet management needs. Those in effect in the Town of Malone as summarized by Jackson (1969a) are typical of the peripheral Adirondack region.

Figure 1. Map of northern New York showing peripheral Adirondack region (stippled) as considered in this study.

of female deer by non-legal means could be controlled. During the first three years, substantial illegal losses of adult females and fawns were documented (Jackson, 1971). Jackson also developed a model of the town's deer poulation which indicated that not all the illegal losses were being recorded.

A contemporary study of reproductive rates of deer throughout the State showed high values for the section that included the Town of Malone (Hesselton and Jackson, 1974). At the same time, a study of the carrying capacity of the deer range in the town (Jackson, 1974a) indicated that available food supplies could sustain a larger population. In fact, while Jackson (1974a) suggested that 20 deer per square mile of wintering area, or 140 deer, might represent the minimum long-term carrying capacity of the range, only about 15 to 25 deer wintered in the town in 1971 (Jackson, 1971). Using data reported by Severinghaus (1967) and Free et al. (1964), Gallman and Sarbello (1975) estimated the deer population in the peripheral Adirondacks as a whole to be only one-quarter to one-third of its potential long-term level which they placed at 12 to 16 deer per square mile of deer range. In a population model, they demonstrated that the removal of a small number of antlerless deer would stabilize the population at a low level.

Department biologists have attributed the illegal deer kill in this region primarily to the attitudes of local residents which make these actions "socially acceptable". They believe that such attitudes are rooted in tradition and have been reinforced by a lack of confidence in the Department's management capabilities and a lack of respect for the Conservation Law as noted by Decker (1976). Early in the study in the Town of Malone (1969), a

questionnaire was sent to a random sample (selected from voter roles) of the local people, requesting information concerning their hunting habits and views regarding deer and the factors affecting them (Jackson, 1969b). As a control, the same questionnaire was sent to a similarly derived sample in the Town of Potsdam, also in Franklin County, which was considered comparable. Then, at the conclusion of the study (1974), virtually the same questionnaire was sent to the same samples in both towns (Jackson, 1974b; Sarbello, 1975). Also, following the research in the Town of Malone, a study of the image of the Department's Bureau of Wildlife among opinion leaders and the general public in the peripheral Adirondack region was undertaken (Brown and Decker, 1976). In addition, a study of public opinion in five areas that were to be included in a deer trap-and-transfer program (by the Bureau of Wildlife) was made in 1976 (Brown et al., 1977). An objective of all these studies was to assess public opinion on various aspects of illegal deer hunting, and the present paper discusses the findings.

The surveys conducted as part of the Malone study had two questions dealing with illegal deer hunting. The first listed several deer mortality factors, one of which was poaching, and recipients were asked to indicate their opinion regarding the effect each had on deer numbers, given the response options: no opinion, no effect, slight, moderate and considerable. They then were asked if something should be done about the mortality factor, given the response options: no opinion, yes and no. The responses obtained for the Town of Malone and the Town of Potsdam (control) were reported by Sarbello (1976) and are summarized in Table 1.

The majority of respondents in the 1969 pretest from the two towns (73 and 54 per cent, respectively) recognized that poaching had some effect on deer populations; 60 and 35 per cent, respectively, rating it as moderate to

TABLE 1. PROPORTION (IN PER CENT) OF RESPONDENTS IN TOWNS OF MALONE AND POTSDAM WHO EXPRESSED VARIOUS OPINIONS CONCERNING THE EFFECT OF POACHING ON THE DEER POPULATION*

Town	No opinion	No effect	Some effect		
			Slight	Moderate	Considerable
Malone					
Pretest (1969)	24.8 (103)	2.4 (10)	13.2 (55)	27.9 (116)	31.7 (132)
Post-test (1974)	22.4 (98)	1.8 (8)	17.2 (75)	23.3 (102)	35.2 (154)
Potsdam					
Pretest (1969)	39.1 (169)	6.9 (30)	18.8 (81)	19.2 (83)	16.0 (69)
Post-test (1974)	32.1 (145)	3.1 (14)	19.2 (87)	23.4 (106)	22.1 (100)

*Figures in parentheses represent number of responses in each case.

considerable. The post-test data in 1974 showed little change in the proportion of respondents from the Town of Malone who believed that poaching has a moderate to considerable effect, but there was a noteworthy difference of 10 per cent for respondents in the Town of Potsdam. These data suggest that in the Town of Malone the general public was already aware, when the study began, that poaching affected the deer population. They also suggest that project efforts to increase the level of awareness had no apparent effect in this, the "treatment" town. In the Town of Potsdam, possible reasons for the increase in awareness include an information drift from the Town of Malone, thus impairing it as a true "control", and an increase in interest caused by the pretest questionnaire since the same sample was used for both surveys.

In the study reported by Brown and Decker (1976), 61 public opinion leaders on deer management in the peripheral Adirondacks were interviewed regarding several aspects of illegal deer hunting. Most of them (85 per cent) recognized such hunting as being of widespread occurrence in the region, and over half (54 per cent) felt that the practice was socially acceptable while only 19 per cent felt that it was not. A large proportion (71 per cent) of these individuals felt that the illegal kill limited the deer herd in the region, one-quarter of them feeling that the effect was severe. Well over half (60 per cent) felt that the illegal kill also severely hampered any efforts by the Bureau of Wildlife to increase the deer population. Generally, then, illegal deer hunting was recognized by the opinion leaders as an important factor in deer management in the peripheral Adirondacks.

In the study of proposed trap-and-transfer areas (Brown et al., 1977), a questionnaire was mailed to 926 residents in the six towns involved (Altona

TABLE 2. Proportion (in per cent) of Respondents in Six Towns* in the Peripheral Adirondacks According to Response to Statements in Questionnaire Concerning the Occurrence of Illegal Deer Hunting and Their Attitude Toward It§

Statement	Response		
	Agree	Don't know	Disagree
Illegal deer kills seldom occur	24.2 (218)	29.0 (261)	46.8 (422)
Illegal deer kill is socially acceptable	16.8 (151)	18.0 (162)	65.2 (586)
People convicted of illegal deer kill should be punished more severely	82.0 (739)	9.9 (89)	8.1 (73
A larger deer herd will not result in a higher incidence of deer poaching	25.9 (231)	26.1 (233)	48.0 (428)
Illegal deer kill is a primary factor limiting deer	36.6 (329)	31.5 (283)	31.9 (287)

*See text.

§Figures in parentheses represent number of responses in each case.

in Clinton County, Malone in Franklin County, Norfolk in St. Lawrence County, Alexandria in Jefferson County, Milton and Galway in Saratoga County). In answer to several questions about the illegal deer kill in their towns, respondents indicated that such losses were not considered an uncommon occurrence. Nearly half (47 per cent) disagreed with a statement in the questionnaire implying that deer were seldom taken illegally (Table 2). Nevertheless, the majority of respondents from all towns believed that illegal deer hunting was not socially acceptable, although nearly half believed that the presence of more deer would result in a higher incidence of poaching. Over 80 per cent of the respondents (regardless of rural vs. village residence or hunter vs. nonhunter status) believed that people convicted of killing deer illegally should be punished more severely.

Of all the respondents, 37 per cent considered the illegal kill a primary factor limiting the deer herd, while 32 per cent thought it was not and 31 per cent were not sure. Also, 62 per cent indicated that they believed illegal hunting had a moderate to great effect on the deer herd, while 38 per cent thought it had only a slight or no effect. When compared with several other mortality factors (starvation, dogs, wild predators, cars, accidents, legal hunting), the illegal kill was ranked, significantly, in first place.

To obtain further understanding of attitudes associated with illegal hunting, respondents were asked whom they would report for illegally killing a deer, given certain circumstances or reasons for the act. Three categories of people representing different degrees of acquaintance with the respondent (friends and neighbors, other local residents, and nonlocal persons) were listed in the questionnaire as possible violators. Four reasons for illegally killing a deer, progressively more serious in terms of intent, as derived from Amidon (1968) and Shafer et al. (1972), were given as options plus the additional option "would not report under the above circumstances". The data are summarized in Table 3.

As the degree of wantonness of the violation increased, so did the proportion of respondents who indicated they would report a person killing deer illegally. Also, with respect to the first two reasons, the proportion who would report a violation was inverse to the closeness of acquaintance with the person committing it. However, when either of the last two questions was involved (i.e., "sells deer" or "kills deer for the thrill of killing") acquaintanceship made little difference, apparently because such violations were considered so flagrant that it mattered little who might commit them. Few respondents (8 to 10 per cent) indicated they would not report anyone under any of the circumstances listed. When intepreting these data, one should realize that the sentiments expressed cannot be equated directly with actual reporting behavior. Not everyone who indicated he would report a violation would actually do so upon witnessing one. Nevertheless, they do reflect attitudes on the social acceptability of various reasons for killing deer illegally.

Table 3. Proportion (in per cent) of Respondents Who Would Report the Illegal Killing of a Deer Under Specific Circumstances, According to Degree of Acquaintance With Violator

Circumstance	Degree of acquaintance		
	Friend or neighbor	Other local resident	Nonlocal person
Accidentally shot	26.9 (211)	34.0 (256)	39.4 (291)
Person uses deer for food	33.2 (261)	37.8 (285)	44.0 (325)
Sells deer	79.2 (632)	80.4 (606)	83.9 (620)
Kills deer for thrill of killing	83.6 (656)	83.2 (627)	86.7 (641)
Would not report under above circumstance	9.7 (76)	7.8 (59)	7.8 (58)
Useable responses*	785	754	739
No response	141	172	187

*Basis for percentages.

In summary, the illegal killing of deer is generally recognized in the peripheral Adirondacks as widespread in occurrence and as an important factor hampering efforts by the Department of Environmental Conservation to increase the deer population. Although opinion leaders felt that illegal deer hunting was socially acceptable (which was the Department's assessment of local sentiment), residents in general expressed a contradictory view. The latter clearly indicated it was not acceptable and overwhelmingly felt that those convicted of it should be punished more severely. At the same time, they showed an inclination to tolerate the accidental killing of an illegal deer during the open season or the illegal taking of one for personal food.

These findings imply that the illegal killing of deer may not be as generally socially acceptable in the peripheral Adirondack region as had been supposed. But the fact that it does occur, and to a degree sufficient to prevent an increase in deer abundance under hunting legally limited to bucks only, indicates that some critical, and as yet unidentified, subgroups of the general population are tolerant of illegal deer hunting and that law enforcement efforts have not been adequate to curb the problem. Furthermore, the possibility exists that, although many residents of the region indicated that the practice was not acceptable to them in principle, they may do little to abate it. This, coupled with evidence that the occurrence of illegal deer hunting is generally known, suggests that information and education programs to increase public awareness of the problem would do little more than reinforce attitudes already present as apparently happened in the Town of Malone despite five years of public contact. A strong

extension program, encouraging overt action to reduce the illegal kill, would be needed to improve the situation in this region. Residents need to be motivated to publicly denounce illegal deer hunting and to back this with positive action, such as actually reporting such activity and influencing town justices to impose stiffer fines or jail sentences. While ongoing efforts to increase public awareness of the effect of the illegal kill may reinforce this awareness intermittently, public relations and extension education programs to achieve positive action seem more promising as an effective means of improving the situation.

LITERATURE CITED

AMIDON, P. H. 1968. New York hunters; a comparison of deer law violators and non-violators. M.S. thesis, N.Y.S. Univ. Coll. Forestry Library.

BROWN, T. L., AND D. J. DECKER. 1976. Identification of the image of the Bureau of Wildlife (NYSDEC) held by residents in the peripheral Adirondack area of New York. New York Federal Aid in Fish and Wildlife Restoration Project W-145-R (final report). N.Y.S. Dept. Environ. Cons. (mimeo.)

BROWN, T. L., D. J. DECKER AND D. HUSTIN. 1977. Public response to deer trap and transfer in the peripheral Adirondacks: determination of favorable initial sites for releasing deer. Dept. Nat. Res., Cornell Univ. (multilith.)

DARROW, R. W. 1948. The whitetail in New York. N.Y.S. Conservationist 2(3):10-13.

DECKER, D. J. 1976. The influence of internal communication on the development of the Bureau of Wildlife's public image in relation to deer management in the peripheral Adirondack region of New York State. M.S. thesis, Cornell Univ. Library.

FREE, S., W. T. HESSELTON AND C. W. SEVERINGHAUS. 1964. The gains and losses in a deer population for five sections of New York State. New York Federal Aid in Fish and Wildlife Restoration Project W-89-R (separate report). N.Y.S. Cons. Dept. (mimeo.)

GALLMAN, N. F., JR., AND W. SARBELLO. 1975. Deer hunting — the peripheral Adirondacks. N.Y.S. Conservationist 30(3):33.

HESSELTON, W. T., AND L. W. JACKSON. 1974. Reproductive rates of white-tailed deer in New York State. N.Y. Fish and Game Jour. 21(2):135-152.

JACKSON, L. W. 1969a. The white-tailed deer in Malone. New York Federal Aid in Fish and Wildlife Restoration Project W-89-R-14 (special report for Job IV-3). N.Y.S. Cons. Dept. (mimeo.)

_____ 1969b. Results of the feasibility portion of the Malone deer study. New York Federal Aid in Fish and Wildlife Restoration Project W-89-R-14 (separate report for Job IV-3). N.Y.S. Cons. Dept. (mimeo.)

_____ 1971. Annual deer mortality in Malone. New York Federal Aid in Fish and Wildlife Restoration Project W-89-R-15 (progress report for Job XI-4). N.Y.S. Dept. Environ. Cons. (mimeo.)

_____ 1974a. Carrying capacity of the deer range in the Town of Malone. N.Y. Fish and Game Jour. 21(1):47-57.

_____ 1974b. A public opinion survey in the Town of Malone with Potsdam as the control town. New York Federal Aid in Fish and Wildlife Restoration Project W-89-R-18 (progress report for Job XI-1). N.Y.S. Dept. Environ. Cons. (mimeo.)

SARBELLO, W. 1975. A public opinion survey in the Town of Malone with Potsdam as the control town. New York Federal Aid in Fish and Wildlife Restoration Project W-89-R-19 (progress report for Job XI-1). N.Y.S. Dept. Environ. Cons. (mimeo.)

_____ 1976. A public opinion survey in the Town of Malone with Potsdam as the control town. New York Federal Aid in Fish and Wildlife Restoration Project W-89-R-20 (progress report for Job XI-1). N.Y.S. Dept. Environ. Cons. (mimeo.)

SEVERINGHAUS, C. W. 1967. What are the prospects for an annual harvest of 13,000 to 26,000 adult bucks from the peripheral Adirondacks. N.Y.S. Cons. Dept. (mimeo.)

Severinghaus, C. W., and C. P. Brown. 1956. History of white-tailed deer in New York. N.Y. Fish and Game Jour. 3(2):129-167.

Severinghaus, C. W., and S. Free. 1963. Management implications of the trend and distribution of the legal deer kill in the Adirondack region. N.Y. Fish and Game Jour. 10(2):201-214.

Shafer, E. L., Jr., P. H. Amidon and C. W. Severinghaus. 1972. A comparison of violators and nonviolators of New York's deer hunting laws. Jour. Wildl. Mgt. 26(3):933-939.

AN ESTIMATE OF THE RECREATIONAL HARVEST OF HARD CLAMS FROM GREAT SOUTH BAY, NEW YORK[1]

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ABSTRACT

A creel-census-type survey of the recreational fishery for hard clams in Great South Bay was made in 1977 to determine if it was important enough to warrant consideration in resource management planning. The recreational harvest was estimated from the degree of effort as determined from random field observations and the catch per unit of effort as derived from interviews with participants. In order to expand single-instance observations along the sampling route into estimates of total activity over a full day, data on the distribution of activity throughout the day were recorded for a representative area. The recreational harvest for the season was estimated at 4.796 bushels, which was 1.42 per cent of the reported commercial landings for the summer months and 0.73 per cent of those for the whole year. Thus, the recreational harvest appears to be of relatively little significance in conservation of the resource.

A creel-census-type survey of the recreational fishery for hard clams (*Mercenaria mercenaria*) in Great South Bay was made in 1977. The study was undertaken primarily to estimate the recreational harvest to determine if it was of enough importance, compared with the large commercial harvest, to warrant consideration in resource management planning.

Great South Bay is located on the south shore of Long Island in Suffolk County and is protected from the Atlantic Ocean by a barrier beach. The bay is a shallow tidal estuary with a mean depth of less than 2 meters and a usual tide range of 0.5 meter. For the purpose of this study, it was considered to be the 25,000 hectares of water bounded on the west by the Nassau-Suffolk County line and on the east by Smith Point (Figure 1). Great South Bay's extensive naturally productive habitat contributed approximately 92 per cent of New York's commercial hard clam landings in 1977 with a reported dockside value in excess of 16.7 million dollars (Leonard Wood, N.Y.S. Department of Environmental Conservation, personal communication). At the time of the study, 25 per cent of the bay's bottom was either privately owned or leased to shellfish companies by town governments. Power dredging was permitted on lands under private control, but harvest methods in the remaining public area were restricted to hand implements such as tongs and rakes.

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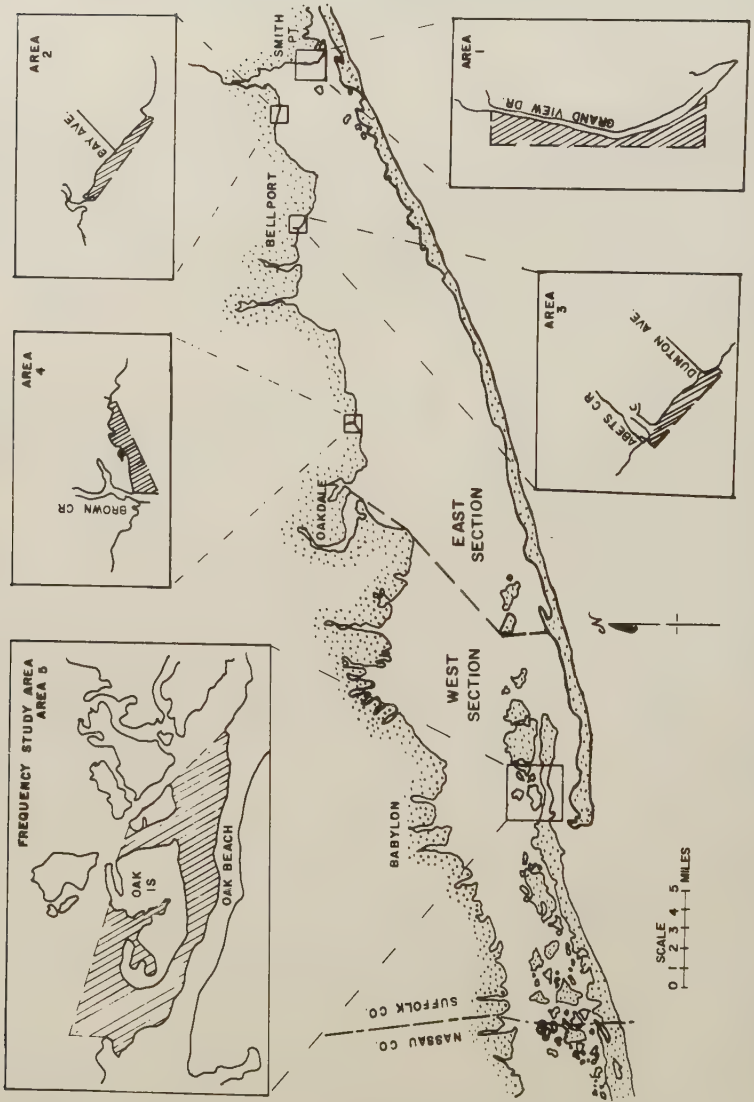

Figure 1. Map of Great South Bay showing extent of western and eastern sections as designated for studying the recreational fishery for hard clams and the locations of the shore-side observation areas.

METHODS

The quantity of hard clams harvested from public areas of Great South Bay by recreational shellfishermen was estimated from the degree of effort (hours) as derived from field observations and the average catch per unit of effort as derived from interviews with participants. A preliminary survey in 1976 served to indicate the length of the season, the degree of activity to be expected and the observer effort needed for the study (Fox, 1977).

Field observations were made from May 29 to September 30 in 1977. Because the size of Great South Bay prohibited covering the entire area during a single observation trip, the bay was divided into eastern and western sampling sections on which observations were made separately. Since the preliminary survey had indicated that the amount of recreational effort on weekdays differed from that on weekend days (including holidays), a separate sampling schedule was developed for each situation. The number of days chosen for each month (June, July, August and September) varied from seven to 12 for weekdays and from two to six for weekend days, being about evenly divided between the two sections in each case. Because of differences in the degree of effort over the summer, the data were analyzed by month as well as for the season as a whole.

To avoid bias due to weather conditions, all sampling days were assigned randomly, and the resulting schedule was strictly followed. However, it was anticipated that, because of random scheduling, there would be days when adverse weather or equipment down-time would preclude operating an observation boat over the entire sampling route, and a plan for shore-side observation of selected clamming areas was developed for such occasions. Five areas were selected: Areas 1 to 4 were located in the eastern section of the bay and Area 5 was in the western section (Figure 1). Data for these areas were equated to those for the entire east or west sampling route according to the ratio between the records from the two types of observation in each section.

Observations were usually made by a two-person team from an outboard motorboat operated along a route covering all of one section or the other. Individuals engaged in recreational clamming were counted and recorded in half-hour time blocks. Recreational clammers were distinguished from commercial shellfishermen by the methods and gear used. A sub-sample of those observed, usually about 10 per cent, were interviewed by the observation team as it progressed along the route. Information recorded during such interviews included the anticipated catch and duration of the trip, as well as the number of clams actually caught and the time spent clamming up until the time of the interview. Participants were also asked to estimate their clamming activity in terms of the number of trips expected during the season. Samples of the clams taken were counted and weighed as a basis for converting the numbers recorded to equivalent 31.75-kilogram (70-pound) bushels for comparison with data for the commercial harvest.

A measure of patterns of recreational activity during the day was needed in order to expand single-instance observations along the route into estimates of the total activity over a full day. A popular recreational clamming area, accessible by motor vehicle or boat, was selected for determining the distribution of such activity from 9 a.m. to 6 p.m. for weekdays and weekend days each month. The area selected was the vicinity of Oak Island which also constituted the shore-side observation area in the western section (Area 5). Counts of recreational clammers on this area were recorded each hour on the hour during 25 randomly assigned weekdays and 12 weekend days over the season. No consideration was given to arrivals or

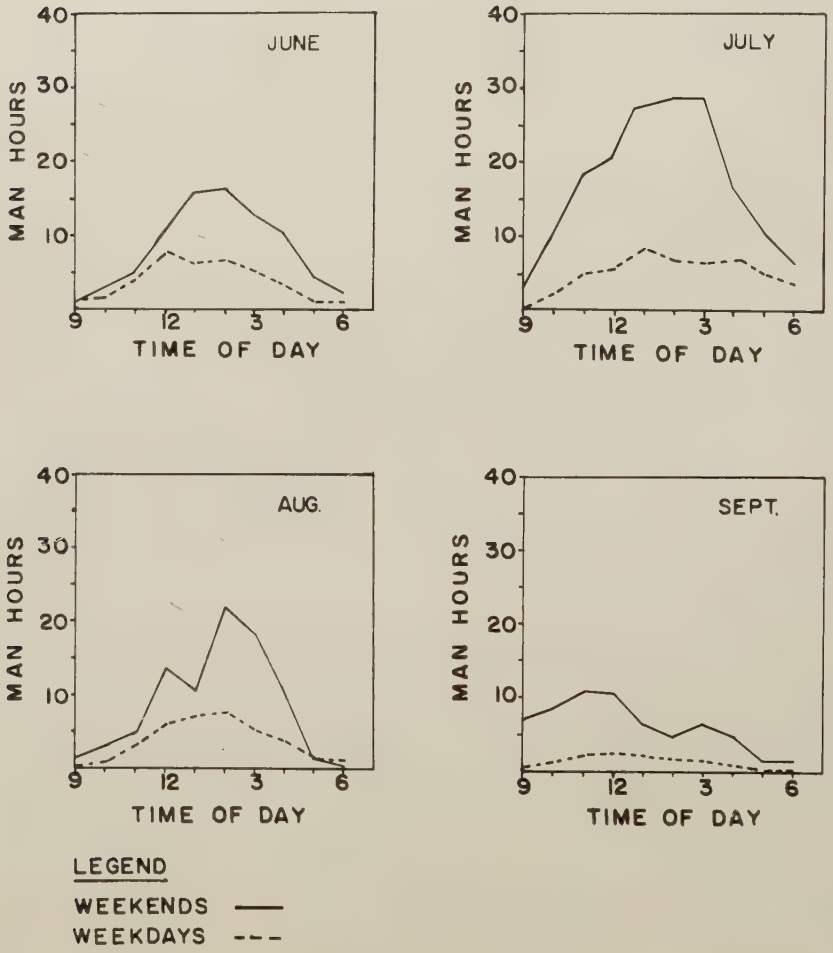

Figure 2. Variation in man hours of recreational clamming during the day in Great South Bay for June, July, August and September.

departures of individuals during the day, so that the resulting information represented man hours of activity as derived from 10 on-the-hour observations rather than the number of individuals involved. The average values for each month are shown in Figure 2.

Multiplying the number of recreational clammers observed during a half-hour time block along the route by the reciprocal of the percentage of total activity represented by the nearest clock hour for the appropriate month gave an estimate of the total for the day for the part of the route covered during that half hour. For example, for weekend days in July the man hours recorded between 9 a.m. and 6 p.m. totalled 171, while the value at 2 p.m. was 29.25 or 17.11 per cent of the total. The reciprocal of 0.1711 is 5.84. If 20 clammers were actually observed on part of a sampling route in the half-hour between 2:00 and 2:30 p.m., then multiplying that number by 5.84 would give 116.8 man hours as the total for the day in that locality. Repeating this process for each segment of the route, as represented by half-hour time blocks, provides an estimate of the total number of man hours on the sampling day.

TABLE 1. SAMPLING DATA AND ESTIMATED TOTAL RECREATIONAL CLAMMING IN GREAT SOUTH BAY IN 1977

Month and period	Sampling effort			Data for sampled days		Estimated total clamming (man hours)
	Days available	Days sampled		Clammers observed	Estimated man hours§	
		Western section	Eastern section			
June*						
Weekends	10	6	4	332	1,998	3,381
Weekdays	23	10	12	409	1,377	2,850
Total				741	3,375	6,231
July						
Weekends	11	3	5	1,186	5,099	14,362
Weekdays	20	8	11	823	4,370	9,000
Total				2,009	9,469	23,362
August						
Weekends	8	2	3	709	3,042	9,077
Weekdays	23	11	12	1,397	5,034	9,914
Total				2,106	8,076	18,991
September						
Weekends	9	3	2	335	1,376	4,984
Weekdays	21	7	8	139	409	1,150
Total				474	1,785	6,134
Total						
Weekends	38	14	14	2,562	11,515	31,804
Weekdays	87	36	43	2,768	11,190	22,914
Total				5,330	22,705	54,718

*The number of days available in June total 33 because, for convenience, May 29 and 30 (Sunday and Memorial Day) were included as June weekend days, and May 31 (Tuesday) as a June weekday.

§Expanded "whole day" values not only for the clammers actually observed but also for those who would have been observed if the tour boats had continued travelling the sampling route all day.

Table 2. Recreational Clammers Interviewed, Their Catch and Trips Made, and Estimated Totals For Great South Bay in 1977

Month and period	Clammers interviewed				Estimated total	
	Number	Average duration of trip (hours)	Average catch (bushels)		Catch* (bushels)	Clammer trips§
			Per trip	Per man hour		
June						
Weekends	27	1.89	0.247	0.131	443	1,794
Weekdays	34	1.37	0.167	0.122	348	2,084
Total	61	xx	xx	xx	791	3,878
July						
Weekends	184	2.05	0.189	0.092	1,321	6,989
Weekdays	68	2.26	0.176	0.078	702	3,989
Total	252	xx	xx	xx	2,023	10,978
August						
Weekends	82	1.44	0.135	0.094	853	6,319
Weekdays	114	1.65	0.120	0.073	724	6.033
Total	196	xx	xx	xx	1,577	12,352
September						
Weekends	42	1.38	0.087	0.063	314	3,609
Weekdays	21	2.07	0.164	0.079	91	555
Total	63	xx	xx	xx	405	4,164
Total						
Weekends	335	xx	xx	xx	2,931	18,711
Weekdays	237	xx	xx	xx	1,865	12,661
Total	572	xx	xx	xx	4,796	31,372

*Derived by multiplying the total man hours from Table 1 by the catch per man hour reported by the clammers interviewed.

§Derived by dividing the estimated total catch by the catch per trip reported by the clammers interviewed.

RESULTS

The records for the sampling done, together with the estimated total number of man hours of recreational clamming in Great South Bay, for weekdays and weekend days each month, are summarized in Table 1. Over the season 5,330 individuals were observed and the estimated time spent by all recreational clammers was 54,718 man hours.

A total of 572 clammers were interviewed concerning their trips and catch. The data are summarized in Table 2. Trips averaged 1.74 hours, and the catch averaged 0.153 bushel per trip. Interviews indicated that individuals made an average of 14.4 trips per season. From this, based on an estimated total of 31,372 trips, it may be inferred that 2,179 persons harvested hard clams from Great South Bay in 1977.

In Table 3 the recreational catch (4,796 bushels) is compared with the reported commercial landings from Great South Bay in 1977, both for the months of June to September (337,191 bushels) and for the whole year (658,443 bushels).

TABLE 3. COMPARISON OF RECREATIONAL AND COMMERCIAL HARVESTS OF HARD CLAMS IN GREAT SOUTH BAY IN 1977

Month	Commercial landings* (bushels)	Recreational harvest	
		Bushels	Per cent§
June	79,153	791	1.00
July	99,209	2,023	2.04
August	87,781	1,577	1.80
September	71,048	405	0.57
Total	337,191	4,796	1.42
Annual	658,443	4,796	0.73

*Data from Leonard Wood (personal communication).
§Relation to commercial landings.

DISCUSSION

The period of May 29 to September 30, during which this survey was made in 1977, encompasses the major recreational clamming activity in Great South Bay. The last days of May and the month of June accounted for 16.5 per cent of the season's harvest, with most of it being taken in the latter part of June. Peak activity occurred during July and August which together accounted for 75.1 per cent of the total. September contributed only 8.4 per cent, with little clamming being done in the latter part of the month.

Recreational clamming in Great South Bay is markedly more intensive on weekends (and holidays) than on weekdays. The 38 weekend days included in this study comprised only 30.4 per cent of the season and yet accounted for 61.1 per cent of the harvest. Only in August did the weekday catch approach the size of the weekend catch, which may be attributed to several days of inclement weather that diminished the weekend catch.

Although an estimated 2,179 individuals took some 4,796 bushels of hard clams in 1977, recreational clamming appears to be of relatively little significance in conservation of the resource since this harvest was only 1.42 per cent of the commercial harvest during the same period and only 0.73 per cent of the total reported commercial landings of 658,443 bushels from Great South Bay in 1977.

LITERATURE CITED

FOX, RICHARD E., 1977. Investigation of the hard clam resources of Great South Bay, New York. Natl. Mar. Fish. Serv., Annual Report for N.Y. Project 3-263-R under Comm. Fish. Res. and Devel. Act (Contract 04-6-043-44061).

FOOD INTERRELATIONSHIPS OF COEXISTING BROOK TROUT, BROWN TROUT AND YEARLING RAINBOW TROUT IN TRIBUTARIES OF THE SALMON RIVER, NEW YORK[1]

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ABSTRACT

A total of 267 overyearling salmonids from four tributaries of the Salmon River were examined for diet composition from June through September during 1977-1979. The specimens were grouped in six categories, i.e., wild yearling rainbow trout, yearling rainbow trout of hatchery origin, large brown trout, small brown trout, large brook trout and small brook trout. Terrestrial annelids, trichopterans, semi-aquatic vertebrates and decapods comprised the major food of wild rainbow trout, while hatchery fish fed most heavily on trichopterans and decapods. Large brown trout fed principally on decapods, subyearling coho salmon and rainbow trout, and frogs, while small brown trout relied chiefly on decapods. Fish were the primary prey of large brook trout, while trichopterans were important in the diet of both large and small brook trout. Size of the predator appears to be an important factor in both inter- and intraspecific food choice for resident brook trout and brown trout. The diet of hatchery rainbow trout was found to overlap significantly those of small brook trout and small brown trout but not that of wild rainbow trout.

The Salmon River and its tributaries in Oswego County are best known for their annual runs of Pacific salmon (*Oncorhynchus* spp.) in the fall and rainbow trout (*Salmo gairdneri*) in the spring. Research has recently shown that natural reproduction of these fish is substantial in this drainage and that these species are now naturalized in New York (Johnson, 1978). Similar occurrences have also been observed in Michigan (Stauffer, 1975, 1977a), Wisconsin (Niemuth, 1970; Avery, 1974) and Minnesota (Hassinger, 1974; Hassinger et al., 1974). Successful spawning of anadromous salmonids has most often occurred in streams occupied by native brook trout (*Salvelinus fontinalis*) and the introduced brown trout (*Salmo trutta*). Recently, concern has arisen in the midwestern Great Lakes states as to the possible effects of spawning anadromous salmonids on stream-resident salmonids in high quality trout streams.[2] Michigan has pioneered in investigating the effects not only of spawning salmon on stream-resident brown trout (Taube, 1975) but also of predation by brown trout on

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[1]The author wishes to acknowledge Emily Zebisch, Lauri Zicari and Robert Santapaga of the State University of New York College of Environmental Science and Forestry at Syracuse for assistance in the field. Dr. Paul Neth, Robert Engstrom-Heg and Philip Hulbert of the New York State Department of Environmental Conservation critically reviewed the manuscript.

[2]Such effects include not only competition between the juvenile salmon produced and the resident stream trout but also physical impact by the spawning salmon themselves. The latter can be manifested in two ways: (1) large salmon may preempt prime spawning areas since coho salmon, chinook salmon, brook trout and brown trout all spawn during the fall; and (2) later-migrating salmon (such as the coho which may spawn until late November in the Salmon River drainage) may superimpose redds on those of resident trout and destroy them.

juvenile coho salmon (*O. kisutch*) and rainbow trout (Hannuksela, 1969). In Wisconsin, Avery (1974) reported on the potential effects of disruption of brook trout spawning activity by coho salmon.

Although virtually all natural reproduction by anadromous salmonids in the Salmon River system is confined to trout waters, similar concern as to the effect of the fish produced on the stream-resident trout populations has not developed. Except for a few local anglers, fishing for resident trout species is relatively light on most tributaries of the Salmon River. Although some large brown trout (up to 3.5 kilograms) are caught during the spring by anglers fishing with egg sacs for rainbow trout, they are mostly incidental catches and do not represent active fishing for resident trout. During the summer, fishing pressure is extremely light as evidenced by the fact that only six fishermen were encountered during the three summers of field collections for this study. The major reasons for the light pressure probably are a general unawareness that the resident trout provide fishing throughout the season compared with the shorter fishery for the anadromous species and the relative remoteness of the area. Most of the streams are some 80 kilometers from the nearest large metropolitan area (Syracuse)—a distance apparently worth travelling for the larger anadromous salmonids but not for the much smaller resident trout.

Little information exists on the biology of resident trout in the Salmon River system. Greeley (1940) found brook trout, brown trout and rainbow trout to be established in many streams in the region. Johnson (1978) presented information on the growth of brown trout and wild yearling rainbow trout from Orwell, Pekin, Trout and John O'Hara Brooks. Although there is no information concerning the summer food habits of these fish, Johnson and Ringler (1979a) showed that salmon eggs were used extensively by resident trout during the fall in Orwell Brook and that this resulted in a significant increase in their condition factor. The present study was undertaken to examine the summer food habits of overyearling salmonids in these tributaries of the Salmon River and to indicate inter- and intraspecific differences in the foods chosen.

METHODS

Fish were collected in Orwell, Pekin, Trout and John O'Hara Brooks (Figure 1) from June through September during 1977-1979 with a 115-volt A.C. electroshocker and a 3-meter minnow seine. These streams have similar physical characteristics (Johnson, 1978). Also, collections of aquatic invertebrates (with Surber samplers and drift nets) revealed that the species composition and standing crops of most benthic invertebrates in the streams were similar. Most fish were collected between 11:00 a.m. and 3:00 p.m., but in July 1979 yearling rainbow trout were collected at 4-hour intervals for 24 hours to determine their daily feeding periodicity. Immediately after capture the specimens were slit and placed in 10 per

Figure 1. Location of the Salmon River and the tributaries studied.

cent formalin to halt digestive processes. In the laboratory the fish were measured (total length in millimeters) prior to stomach analysis. A correction factor (Stauffer, 1971) was then used to account for shrinkage caused by preservation.

The rainbow trout taken were of two types, i.e., wild fish produced by natural spawning and hatchery fish. The latter were all yearlings and were readily recognized by pelvic fin clips. They had been stocked in the spring at age I +, and most of them migrated to Lake Ontario within 3 months (Johnson 1980). Also, Johnson (1978) found that virtually all wild rainbow trout in the Salmon River system left their natal streams before the age of two.

In general, aquatic invertebrates were identified to family, and terrestrial invertebrates to order. When possible, fish remains were identified to species. The taxonomic keys used were those of Edmundson (1959), Hitchcock (1974), Hilsenhoff (1975), Borror et al. (1976), Edmunds et al. (1976) and Wiggins (1977).

To assess the relative contribution of different organisms to the food of the salmonids examined, average dry weights for specific taxa were determined. For both aquatic and terresrial taxa, a representative number of individuals were dried at 105 ° C. for 24 hours, placed in a desiccator for approximately 6 hours and then weighed. The dry weight of the sample was then divided by the number of specimens to give the average per individual for that taxon. Larger items such as amphibians, fish and decapods were weighed individually.

Values for diet overlap (i.e., the degree to which the composition of the diet is the same among different groups) were calculated using the equation of Morisita (1959) as modified by Horn (1966)

$$C\lambda = 2\frac{\sum_{i=1}^{s} XiYi}{\sum_{i=1}^{s} Xi^2 + \sum_{i=1}^{s} Yi^2}$$

where:

$C\lambda$ = overlap value

s = total items in both categories

Xi = proportion of total diet of fish species X contributed by food taxon i

Yi = proportion of total diet of fish species Y contributed by food taxon i

RESULTS

A total of 267 overyearling salmonids were examined according to six categories as shown in Table 1, and their stomach contents is summarized in Table 2. Very large brown trout (i.e., 350 millimeters or more in length) were not kept for food habits studies.

A greater diversity of foods was found in the wild rainbow trout than in the other categories, although this was probably a result of the greater number of specimens examined. Aquatic, and semi-aquatic (i.e., salamanders, frogs), organisms comprised 58.8 per cent of the total by weight. In order of importance, trichopterans (primarily odontocerids and hydropsychids) — 15.01 per cent, crayfish (Decapoda) — 12.04 per

TABLE 1. NUMBER AND SIZE OF OVERYEARLING SALMONIDS EXAMINED FROM FOUR SALMON RIVER TRIBUTARIES, JUNE - SEPTEMBER, 1977-1979

Category	Number	Length (millimeters)	
		Mean	Range
Rainbow trout			
Wild	118	126	91-182
Hatchery	34	142	98-189
Brown trout			
Large (250-349 millimeters long)	21	291	253-345
Small (under 250 millimeters long)	41	175	112-249
Brook trout			
Large (150 or more millimeters long)	15	177	150-219
Small (under 150 millimeters long)	38	117	80-149

Table 2. Stomach Contents, According to Dry Weight and Frequency of Occurrence, For Overyearling Salmonids From Salmon River Tributaries, June - September, 1977-1979*

Taxon	Rainbow trout				Brown trout				Brook trout			
	Wild		Hatchery		Large§		Small§		Large§		Small§	
	Dry weight	Occurrence	Dry weight	Occurrence	Dry weight	Occurrence	Dry weight	Occurrence	Dry weight	Occurrence	Dry weight	Occurrence
Aquatic organisms												
Turbellaria	..	..	0.12	3	..	..	..	..	..	..	..	..
Oligochaeta	0.01	1	..	..	..	..	..	..	..	..	..	..
Hydracarina	0.01	3	..	..	..	..	..	..	..	..	..	..
Decapoda												
Astacidae	12.04	4	32.51	9	34.78	29	78.60	24	7.95	7	39.82	21
Collembola	0.01	1	..	..	..	..	..	..	..	..	..	..
Plecoptera												
Chlorperlidae	0.03	2	..	..	..	..	..	..	..	..	..	..
Leuctridae	0.29	3	..	..	..	..	0.02	2	..	..	..	..
Nemouridae	..	..	..	..	..	..	0.02	2	..	..	..	..
Perlidae	6.91	18	4.32	12	4.72	29	9.49	22	..	..	..	..
Perlodidae	0.16	3	0.38	6	0.03	5	0.04	2	..	..	0.13	3
Unidentified	1.10	6	0.84	9	..	..	0.53	10	0.37	7	0.48	16
Ephemeroptera												
Baetidae	1.44	25	0.90	24	..	..	0.09	10	..	..	0.19	11
Ephemerellidae	0.68	9	0.31	6	0.02	5	0.15	12	..	..	0.11	3
Ephemeridae	..	..	1.81	9	..	..	..	..	..	..	..	..
Heptageniidae	2.28	14	0.47	6	0.03	5	0.45	15	..	..	..	..
Leptophelebiidae	0.55	11	0.90	18	..	..	0.02	2	..	..	..	..
Siphlonuridae	0.24	3	0.76	6	..	..	..	..	..	..	..	..
Unidentified	1.20	17	0.34	6	..	..	0.10	10	..	..	0.58	18
Odonata	0.18	2	..	..	..	..	..	..	0.09	7	0.65	3
Hemiptera												
Corixidae	0.07	1	..	..	..	..	..	..	..	..	..	..
Gerridae	..	..	..	..	..	..	0.15	5	..	..	..	..
Trichoptera												
Brachycentridae	0.09	4	0.25	9	..	..	0.24	10	0.06	7	0.04	3
Glossosomatidae	0.23	8	..	..	..	..	0.03	2	..	..	0.04	3
Helicopsychidae	0.47	9	0.28	9	0.06	10	0.07	5	6.45	33	9.45	34
Hydropsychidae	4.26	22	4.54	18	..	..	0.36	10	0.49	7	0.13	3
Hydroptilidae	0.01	1	0.07	3	0.01	5	..	..	..	..	..	..
Leptoceridae	0.14	3	..	..	..	..	0.13	10	..	..	..	..
Limnephilidae	0.49	3	2.87	12	0.32	10	0.44	5	..	..	0.79	5
Odontoceridae	6.45	16	21.31	41	0.10	5	1.21	17	25.92	53	17.09	39
Philopotamidae	0.78	14	.	..	..	..	0.11	7	..	..	..	..
Polycentropodidae	0.04	1	0.39	6	..	..	..	..	..	..	..	..

Rhyacophilidae	0.27	3	..	..	0.04	5	..	..	..	..	..	..
Unidentified	1.78	16	4.00	21	..	..	0.33	12	1.07	13	1.89	16
Megaloptera												
Corydalidae	..	..	..	..	..		0.07	2	..	..	..	..
Coleoptera												
Dytiscidae	0.04	1	0.37	3	..	..	..	..	..	..	..	..
Elmidae	0.34	7	..	..	..	..	0.02	2	..	..	..	..
Psephenidae	0.13	2	0.63	6	0.04	5	0.12	5	0.34	7	..	..
Diptera												
Chironomidae	0.58	45	0.34	41	..	..	0.04	22	0.05	13	0.07	21
Dixidae	0.02	1	..	..	..	..	..	..	..	..	..	..
Empididae	0.01	2	..	..	..	..	..	..	..	..	..	..
Rhagionidae	0.02	1	..	..	..	..	..	..	..	..	..	..
Simuliidae	0.02	1	..	..	..	..	0.03	5	..	..	..	..
Tipulidae	2.02	13	1.79	6	..	..	0.56	10	0.64	7	0.06	3
Urodela†												
Salamandridae	9.08	2	..	..	..	..	..	..	..	..	..	..
Anura†												
Ranidae	4.35	2	..	..	20.41	10	..	..	..	..	..	..
Teleostei†												
Coho salmon (0+)	..	..	..	..	16.30	10	..	..	..	..	..	..
Rainbow trout	..	..	..	..	11.75	10	..	..	..	..	..	..
Blacknose dace	..	..	..	..	10.71	10	..	..	..	..	..	..
Unidentified	..	..	..	..	0.58	5	0.84	2	36.01	13	..	..
Subtotal	58.80	xx	80.50	xx	99.90	xx	94.26	xx	79.44	xx	71.52	xx
Terrestrial organisms												
Annelida	24.39	6	2.99	3	..	..	..	..	..	..	12.00	8
Arachnida	1.04	11	0.64	6	..	..	0.19	7	..	..	0.67	11
Coleoptera	4.72	27	8.10	24	0.08	5	1.44	15	8.56	27	5.14	18
Dermaptera	0.01	3	..	..	..	..	..	..	..	..	0.01	3
Diplopoda	..	..	..	..	..	..	0.30	2	3.26	7	..	..
Diptera	0.99	15	2.12	26	..	..	0.18	12	0.28	13	0.83	18
Hemiptera	0.58	12	0.25	3	0.02	5	0.07	5	1.15	13	0.60	8
Homoptera	1.69	12	0.26	3	..	..	0.06	2	0.84	13	1.45	11
Hymenoptera	2.97	15	2.03	6	..	..	1.05	12	2.56	20	4.83	18
Isopoda	0.13	1	..	..	..	..	..	..	..	..	..	..
Lepidoptera	4.68	12	3.11	6	..	..	2.45	15	3.91	13	2.95	11
Subtotal	41.20	xx	19.50	xx	0.10	xx	5.74	xx	20.56	xx	28.48	xx
Number of stomachs empty	xx	8	xx	1	..	3	xx	8	xx	3	..	3
Total	100.00	118	100.00	34	100.00	21	100.00	41	100.00	15	100.00	38

•Values in percentage.
§See Table 1.
†Vertebrates; all others invertebrates.

cent, salamanders (Salamandridae) — 9.08 per cent, and plecopterans (primarily perlids) — 8.49 per cent were the major prey eaten. Terrestrial invertebrates (41.2 per cent) were eaten to a greater degree by wild rainbow trout than by the other salmonids. Annelids (chiefly earthworms) — 24.39 per cent were the main terestrial prey eaten and also contributed the highest percentage to the diet of any taxon. Of the 118 stomachs examined, eight were empty.

In mid-July 1979 wild rainbow trout were collected from Orwell Brook at 4-hour intervals for 24 hours. Although small samples (4-10 fish) at some intervals precluded detailed analysis, the data suggest that peak feeding occurred between 4:00 a.m. and 8:00 a.m. and between 8:00 p.m. and midnight. Stomachs were emptiest at 4:00 p.m. and 8:00 p.m. At 12 noon, stomachs were moderately full of well digested material which suggests that these fish may have fed most heavily between 4:00 a.m. and 8:00 a.m.

Recently stocked hatchery rainbow trout fed mostly on aquatic invertebrates (80.5 per cent). Trichopterans (primarily odontocerids) — 33.71 per cent and crayfish (32.51 per cent) were the major aquatic prey eaten. Mayfly nymphs (Ephemeroptera) — 5.49 per cent and stonefly nymphs (Plecoptera, primarily perlids) — 5.54 per cent contributed equally to the diet. Among terrestrial invertebrates, coleopterans were the major food. One of the 34 stomachs was empty.

Aquatic and semi-aquatic vertebrates (60.56 per cent) predominated in the stomach contents of the large brown trout examined. Frogs (Ranidae), subyearling coho salmon and rainbow trout, and blacknose dace were the principal vertebrate prey eaten, each being represented by two individuals. Crayfish (Decapoda) and perlid stoneflies were the major aquatic invertebrates eaten. Terrestrial invertebrates contributed only 0.10 per cent. Three of the 21 stomachs examined were empty.

The major prey of the small brown trout examined were crayfish (Decapoda) — 78.60 per cent. The only other aquatic food of importance was perlid stoneflies. Lepidopteran larvae and coleopterans were the main terrestrial invertebrates consumed. Eight of the 41 stomachs were empty.

The principal food of the large brook trout examined was unidentified fish (perhaps cyprinids) — 36.01 per cent and trichopterans (primarily odontocerids and helicopsychids) — 33.99 per cent. Terrestrial organisms, including coleopterans, lepidopterans, diplopoda and hymenopterans, comprised 20.56 per cent. Three of the 15 stomachs examined were empty.

Small brook trout fed most heavily on crayfish (Decapoda) — 39.82 per cent and trichopterans (mainly odontocerids and helicopsychids) — 29.46 per cent. Perlid stoneflies, a common prey of the other salmonids, were not taken by the small brook trout examined. Annelids, coleopterans,

TABLE 3. DIET OVERLAP VALUES FOR OVERYEARLING SALMONIDS FROM SALMON RIVER TRIBUTARIES

Categories§	Value ($C\ \lambda$)
Hatchery rainbow trout—small brook trout	0.9194*
Small brown trout—small brook trout	0.7501*
Hatchery rainbow trout—small brown trout	0.6659*
Large brown trout-large brook trout	0.6312*
Large brown trout—small brown trout	0.5934
Wild rainbow trout—small brook trout	0.5925
Wild rainbow trout—hatchery rainbow trout	0.5402
Large brown trout—small brook trout	0.5162
Hatchery rainbow trout—large brown trout	0.4738
Hatchery rainbow trout—large brook trout	0.4707
Large brook trout—small brook trout	0.4094
Wild rainbow trout—small brown trout	0.2871
Wild rainbow trout—large brown trout	0.2564
Wild rainbow trout—large brook trout	0.2121
Large brook trout—small brown trout	0.1685

*Significant overlap.

§See Table 1.

hymenopterans and lepidopterans were the principal terrestrial invertebrates consumed. Three of the 38 stomachs examined were empty.

Estimates of diet overlap were calculated for all possible combinations of the categories (Table 3). Overlap values ($C\ \lambda$) can vary from 0, when samples contain no foods in common, to 1, when there is identical proportional representation between samples in the foods eaten. In general, values of 0.60 or more are considered significant (Zaret and Rand, 1971; Vaught and Stewart, 1974; Fuller and Stewart, 1977, 1979). Therefore, a significant overlap in diet occurred in four comparisons: hatchery rainbow trout—small brook trout; small brown trout—small brook trout; hatchery rainbow trout—small brown trout; and large brown trout—large brook trout. In addition, the overlap between large brown trout and small brown trout and between wild rainbow trout and small brook trout approached significance. It is interesting that the two closest categories in terms of mean total length, i.e., large brook trout (177 millimeters) and small brown trout (175 millimeters) had the lowest diet association.

DISCUSSION

Limited information is available on the food habits of wild yearling rainbow trout while stream residents. In Michigan, Hannuksela (1973) and Wagner (1975) found that aquatic invertebrates, primarily hydropsychid caddisflies and ephemeropteran nymphs, were eaten chiefly by yearling rainbow trout. Tippets and Moyle (1978) demonstrated that yearling rainbow trout preferred invertebrates with low drift rates in the McCloud River in California. The food habits of wild rainbow trout in the tributaries of the Salmon River were in general agreement with the findings of these

studies although the proportion of vertebrate prey (13.43 per cent) was considerably larger.

The food habits of hatchery rainbow trout have been studied by Kennedy (1967) and Jenkins et al. (1970). Kennedy found that aquatic dipterans, trichopterans and ephemeropterans were the major summer food of such trout. Jenkins and his coworkers, however, observed that the diets of trout reflected diel variation in the invertebrate composition of the stream drift. The diets of hatchery rainbow trout in tributaries of the Salmon River appear to be closely associated with benthic foraging habits. The principal prey of this group, i.e., decapods and heavily cased odontocerid caddis larvae, are organisms that would have extremely low diurnal drift rates.

A voluminous literature exists concerning the feeding habits of stream brown trout. In New York, Raney and Lachner (1942) and Webster and Little (1942) examined the food habits of recently stocked brown trout. Other authors (Clemens, 1928; Idyll, 1942; Lorz, 1974; Wagner, 1975; Stauffer, 1977b) have shown that insects (both aquatic and terrestrial) compose most of the diet of brown trout less than 200 millimeters long. The dominant forage of smaller brown trout in the present study, however, was decapods (crayfish). Johnson (1978) noted that crayfish were very abundant in Orwell, Pekin, Trout and John O'Hara Brooks and suggested that their high standing crops may have been related to the tremendous number of Pacific salmon carcasses available for scavenging. Spawning activity of Pacific salmon may also affect the number of perlid stoneflies in these streams. Perlids, which contribute highly to the diets of most salmonids, have been shown to prey on salmonid embryos within the gravel (Claire and Phillips, 1968). The tremendous egg deposition by Pacific salmon in the fall and by rainbow trout in the spring could create an abundant food supply for perlid nymphs. Johnson and Ringler (1979a, 1979b) found that salmon eggs and blow-fly larvae washed into the stream from decomposing salmon carcasses contribute substantially to the diet of subyearling and yearling salmonids in Orwell Brook during the fall.

The piscivorous food habits of large brown trout are well known (Idyll, 1942; Staley, 1966; Hannulsela, 1969). Idyll and Hannuksela reported that the principal fish eaten by such trout were salmonids, and Hannuksela demonstrated that brown trout selected salmonids over sculpins in the Anna River in Michigan. Although the sample (21) was somewhat small, data from the Salmon River tributaries suggest that salmonids (28.05 per cent) are a major component of the diet of large brown trout. Since brown trout 350 millimeters or more in length were not examined, and since brown trout generally prey increasingly on fish as they grow larger, it may be that their diet includes a higher proportion of salmonids than that of the fish examined.

The food habits of both large and small brook trout in the Salmon River

tributaries were very similar to those reported in the literature. Trichopterans generally are the principal food of stream brook trout (Clemens, 1928; Ricker, 1930; Ide, 1942; Tebo and Hassler, 1963; Needham, 1969). Clemens and Ricker found that large brook trout (8-10 inches) fed most heavily on fish, trichopterans and terrestrial insects in New York and Ontario streams. These taxa were also the major food of large brook trout in the present study.

Few studies have examined feeding interrelationships among the categories of salmonids as recognized in this study. Wagner (1975) found significant correlations between the diets of yearling rainbow trout and brown trout in the Platte River in Michigan. Nyman (1970) observed no marked difference between stream-resident brook trout and brown trout in the foods selected. In the Salmon River system there was little diet overlap between wild yearling rainbow trout and small brown trout (Table 3). However, growth data (Johnson, 1978) indicate that small brown trout, as defined here, included ages up to III + so that a direct comparison with Wagner's data for yearlings cannot be made. The significant diet overlaps observed between small brown trout and small brook trout and between large brown trout and large brook trout, as well as the non-significant overlaps found between large brown trout and small brook trout and between large brook trout and small brown trout, suggest that size is an important factor in food selection between these two species. The data also suggest that size is important in intraspecific food selection as neither the diet overlap between large brown trout and small brown trout nor that between large brook trout and small brook trout was significant.

The diet of hatchery rainbow trout was found to overlap significantly those of small brook trout and small brown trout. This suggests that the stocking of hatchery rainbow trout may have a greater effect on stream-resident salmonids than on wild yearling rainbow trout. In fact, the mean diet overlap between hatchery rainbow trout and the other five categories collectively was significant (0.6140), whereas that between wild rainbow trout and the other categories was not (0.3778).

Analysis of the food habits of overyearling salmonids in the Salmon River system revealed that hatchery rainbow trout were using the same prey as stream-salmonids and wild rainbow trout. However, the extremely short stream residency (1-3 months) of these fish probably results in a minimal impact on the other salmonid groups. The largest impact observed in this study may have been the effect of the larger resident brown trout on naturally reproduced subyearling coho salmon and rainbow trout.

LITERATURE CITED

AVERY, E. L. 1974. Reproduction and recruitment of anadromous salmonids in Wisconsin tributaries of Lake Michigan. Wisc. Dept. Nat. Resources.

BORROR, D. J., D. M. DELONG AND C. A. TRIPLEHORN. 1976. An Introduction to the Study of Insects (4th ed.). Holt, Rinehart and Winston, New York, N.Y.

CLAIRE, E. W., AND R. W. PHILLIPS. 1968. The stonefly *Acroneuria pacificia* as a potential predator on salmonid embryos. Trans. Am. Fish. Soc. 97:50-53.

CLEMENS, W. A. 1928. Food of trout from the streams of Oneida County, New York State. Trans. Am. Fish. Soc. 58:183-197.

EDMONDSON, W. T. 1959. Freshwater Biology. John Wiley and Sons, New York.

EDMUNDS, G. F., S. L. JENSEN AND L. BERNER. 1976. The Mayflies of North and Central America. Univ. Minnesota Press, Minneapolis, Minn.

FULLER, R. L., AND K. W. STEWART. 1977. The food habits of stoneflies (Plecoptera) in the Upper Gunnison River, Colorado. Environ. Entomol. 6:293-302.

_____ 1979. Stonefly (Plecoptera) food habits and prey preference in the Dolores River, Colorado. Am. Midl. Nat. 101:170-181.

GREELEY, J. R. 1940. Fishes of the area with annotated list. In: A Biological Survey of the Lake Ontario Watershed. N.Y.S. Cons. Dept.:42-81.

HANNUKSELA, P. R. 1969. Food habits of brown trout in the Anna River, Alger County, Michigan. Mich. Dept. Nat. Resources, Res. Devel. Rept. 186.

_____ 1973. Food interrelationships of the mottled sculpin, *Cottus bairdi*, and juveniles of rainbow trout, *Salmo gairdneri*, in a tributary of Lake Superior. Mich. Dept. Nat. Resources, Res. Devel. Rept. 1801.

HASSINGER, R. 1974. Evaluation of coho salmon (*Oncorhynchus kisutch*) as a sport fish in Minnesota. Minn. Dept. Nat. Resources, Invest. Rept. 328.

HASSINGER, R. L., J. G. HALE AND D. E. WOODS. 1974. Steelhead of the Minnesota north shore. Minn. Dept. Nat. Resources, Tech. Bull. 11.

HILSENHOFF, W. L. 1975. Aquatic insects of Wisconsin with generic keys and notes on biology, ecology and distribution. Wisconsin Dept. Nat. Resources, Tech. Bull. 89.

HITCHCOCK, S. W. 1974. Guide to the insects of Connecticut: Pt. VII. The Plecoptera or stoneflies of Connecticut. State Geol. Nat. Hist. Surv. Conn., Bull. 107.

HORN, H. S. 1966. Measurement of "overlap" in comparative ecological studies. Am. Nat. 100:419-424.

IDE, F. P. 1942. Availability of aquatic insects as food of the speckled trout, *Salvelinus fontinalis*. Trans. N. Am. Wildl. Conf. 7:442-450.

IDYLL, C. 1942. Food of rainbow, cutthroat, and brown trout in the Cowichan River system, B.C. Jour. Fish. Res. Bd. Canada 5:448-458.

JENKENS, T. M., JR., C. R. FELDMETH AND G. V. ELLIOT. 1970. Feeding of rainbow trout (*Salmo gairdneri*) in relation to abundance of drifting invertebrates in a mountain stream. Jour. Fish. Res. Bd. Canada 27:2356-2361.

JOHNSON, J. H. 1978. Natural reproduction and juvenile ecology of Pacific salmon and steelhead trout in tributaries of the Salmon River, New York. M.S. thesis, State Univ. New York College Environ. Sci. and Forestry at Syracuse.

_____ 1980. Production, growth and summer-to-autumn survival of juvenile steelhead trout in four Salmon River tributaries. Paper presented at 1980 meeting of New York Chapter of the Am. Fish. Soc. at Marcy, N.Y.

JOHNSON, J. H., AND N. H. RINGLER. 1979a. Predation on Pacific salmon eggs by salmonids in a tributary of Lake Ontario. Jour. Great Lakes Res. 5:177-181.

_____ 1979b. The occurrence of blow-fly larvae (Diptera: Calliphoridae) on salmon carcasses and their utilization as food by juvenile salmon and trout. Great Lakes Entomol. 12:137-140.

KENNEDY, H. D. 1967. Seasonal abundance of aquatic invertebrates and their utilization by hatchery-reared rainbow trout. U.S. Fish and Wildl. Serv., Tech. Paper 12.

LORZ, H. W. 1974. Ecology and management of brown trout in Little Deschutes River, Oregon Wildl. Comm., Res. Rept. 8.

MORISITA, M. 1959. Measuring of interspecific association and similarity between communities. Mem. Fac. Sci. Kyushu Univ., Ser. E (Biology) 3:65-80.

NEEDHAM, P. R. 1969. Trout Streams (2nd ed.). Holden-Bay Inc., San Francisco, Calif.

NIEMUTH, W. 1970. A study of migratory lake run trout in the Brule River, Wisconsin: Pt. 11—rainbow trout. Wis. Dept. Nat. Resources, Fish Mgt. Rept. 38.

NYMAN, O. L. 1970. Ecological interaction of brown trout, *Salmo trutta* L., and brook trout, *Salvelinus fontinalis* (Mitchill), in a stream. Can. Field-Nat. 84:343-350.

RANEY, E. C., AND E. A. LACHNER. 1942. Autumn food of recently planted young brown trout in small streams in central New York. Trans. Am. Fish. Soc. 71:106-111.

RICKER, W. E. 1930. Feeding habits of speckled trout in Ontario waters. Trans. Am. Fish. Soc. 60:64-72.

STALEY, J. 1966. Brown trout. In: Inland Fisheries Management (Alex Calhoun, Ed.): 233-242. Calif. Dept. Fish and Game.

STAUFFER, T. M. 1971. Salmon eggs as food for stream salmonids and sculpins. Mich. Dept. Nat. Resources, Res. Devel. Rept. 233.

_____ 1975. Population characteristics and summer-to-autumn survival of juvenile rainbow trout and coho salmon in two Lake Superior tributaries, 1969-1972. Mich. Dept. Nat. Resources, Res. Rept. 1825.

_____ 1977a. Numbers of juvenile salmonids produced in five Lake Superior tributaries and the effect of juvenile coho salmon on their numbers and growth 1967-1974. Mich. Dept. Nat. Resources, Fish Res. Rept. 1846.

_____ 1977b. A comparison of the diet and growth of brown trout (*Salmo trutta*) from the South Branch and the Main Stream, Ausable River, Michigan. Mich. Dept. Nat. Resources, Fish. Res. Rept. 1845.

TAUBE, C. M. 1975. Abundance, growth, biomass, and interrelationships of trout and coho salmon in the Platte River. Mich. Dept. Nat. Resources, Fish. Res. Rept. 1830.

TEBO, L. B., JR., AND W. W. HASSLER. 1963. Food of brook, brown and rainbow trout in streams in western North Carolina. Jour. Elisha Mitchell Sci. Soc. 79:44-53.

TIPPETS, W. E., AND P. B. MOYLE. 1978. Epibenthic feeding by rainbow trout (*Salmo gairdneri*) in the McCloud River, California. Jour. Animal Ecol. 47:549-559.

VAUGHT, G. L., AND K. W. STEWART. 1974. The life history and ecology of the stonefly *Neoperla clymene* (Newman) (Plecoptera: Perlidae). Ann. Entomol. Soc. Am. 67:167-178.

WAGNER, W. C. 1975. Food habits of coexisting juvenile coho salmon, brown trout and rainbow trout in Platte River, 1967 and 1972. Mich. Dept. Nat. Resources, Fish. Res. Rept. 1831.

WEBSTER, D. A., AND G. S. LITTLE. 1942. Food of newly planted adult brown trout (*Salmo trutta*) in Six Mile Creek, New York. Copeia 3:192.

WIGGINS, G. B. 1977. Larvae of the North American Caddisfly Genera. Univ. Toronto Press, Toronto.

ZARET, T. M., AND A. S. RAND. 1971. Competition in tropical stream fishes: support for the competitive exclusion principle. Ecology 52:336-342.

CHARACTERISTICS OF FALL AND SPRING MIGRANT RAINBOW TROUT IN CAYUGA INLET, NEW YORK[1]

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ABSTRACT

The fall and spring migrations of rainbow trout in Cayuga Inlet were studied over a 5-year period to assess their relative importance to annual egg production. Differences in age composition, sex ratio and length composition indicated that younger fish moved upstream earlier in the pre-spawning migration than older fish. The fall runs were dominated by males, which were generally younger than the females. Fall-run rainbow trout probably made an important contribution to the annual production of viable eggs in Cayuga Inlet.

Spawning migrations of rainbow trout (*Salmo gairdneri*) are often characterized by two distinct intervals of upstream movement (fall and spring) separated by one or more weeks of no upstream movement. Two-run migration habits have been documented for rainbow trout in the Finger Lakes in New York (Hartman, 1959) and the Great Lakes (Dodge and MacCrimmon, 1971; Hassinger et al., 1974). Similar habits have been described for steelhead (sea-run rainbow) trout on the Pacific Coast of North America (Withler, 1966; Narver, 1969). In Cayuga Inlet, a tributary of Cayuga Lake (one of the Finger Lakes), the fall run usually begins in mid-October and lasts until mid-January to early February, while the spring run begins in late February and ends in early May.

In-stream behavior of the fall migrants varies. For example, Dodge and MacCrimmon (1971) reported spawning activity of fall migrants during the winter in a tributary of Lake Huron, whereas Hassinger et al. (1974) noted that fall migrants in a tributary of Lake Superior generally returned to the lake before freeze-up. Hartman (1959) sampled a few ripe female rainbow trout during November and December in tributaries of the Finger Lakes, but he postulated that fall-run fish probably comprised part of the spring spawning populations.

Beginning in 1976, fishing for rainbow trout in Cayuga Inlet was permitted during the fall (October through December) with a minimum size limit of 10 inches[3] (25.4 centimeters). If the contribution to the annual production of viable eggs by fall migrants is substantial, then the fall in-stream fishery could jeopardize future population levels. Data recorded by

[1]Derived in part from a Ph.D thesis submitted to the Graduate School at Cornell University. The author wishes to thank Paul Neth and Ernest Lantiegne of the New York State Department of Environmental Conservation for reviewing the manuscript and providing constructive comments. The study was funded through New York Federal Aid in Fish and Wildlife Restoration Project FA-1-R.

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[3]This was reduced to 9 inches the following year.

the author a few years earlier afford an opportunity to compare the life history characteristics of fall-run and spring-run rainbow trout in Cayuga Inlet and to assess the relative importance of each run to the annual egg production of the population.

STUDY SITES

Cayuga Inlet is one of the major tributaries of Cayuga Lake and enters the lake at its southern end. It is about 18.4 kilometers in length with an average gradient of 11.6 meters per kilometer. The Inlet and its tributaries comprise approximately 30 of the 54 kilometers of unobstructed stream habitat accessible from the lake and constitute its largest spawning and nursery system for rainbow trout (Seifert, 1968).

A drop structure with a denil-type fishway and trapping facility, 3.2 kilometers upstream from its mouth, serves as a permanent station for sampling migrant fish. Below the drop structure the level of the Inlet is equal to that of Cayuga Lake. The fishway system was constructed in 1969 as part of a flood-control program sponsored by the U.S. Army Corps of Engineers in cooperation with Cornell University, the State of New York and the U.S. Fish and Wildlife Service. Webster and Otis (unpublished)[4] gave specific technical details on the design and operation of the fishway system.

METHODS

During the period of this study (1969-1974), the fishway was tended almost daily during the rainbow trout runs. The following data were collected for each trout removed from the trap: sex, length, weight, condition of gonads, and the number of lamprey scars and wounds. A scale sample was removed from each fish for subsequent age determination. Rainbow trout more than 30 centimeters long were tagged with a mandible ring prior to release. During each migration all fish were released immediately above the trap, except for approximately 100 females and 50 males that were held for artificial spawning.

Criteria for aging the trout by scale reading were those of Hartman (1959). In the present paper, ages are expressed in terms of the number of stream and lake growing seasons as exhibited on the scales by zones of widely spaced circuli, instead of the number of annuli. The classification based on growing seasons is used to facilitate comparing the ages of fall and spring migrants.

Rainbow trout held for artificial spawning were kept in holding pens at the fishway. Water in the pens was continually replenished by the flow

[4]D. A. Webster and M. B. Otis. [1973] Two New York facilities for fishery research and management: Fish passage and collection on Cayuga Inlet and pilot artificial spawning and circulation channel at Myers Point, Cayuga Lake. Dept. Nat. Resources, Cornell Univ. (mimeo.)

through the fishway system. In March, these fish were transferred to holding tanks at the Cornell University Fishery Laboratory where they were held until ripe. Eggs were removed from females by manual stripping (1970-1973) or by injecting air into the body cavity (1974). Milt was stripped from two or three males to insure fertilization of the eggs from each female. Spawned fish were released in upper Cayuga Inlet. The fertilized eggs were tallied with a photoelectric counter and placed in vertically stacked trays for incubation after being water-hardened. When the eggs reached the eyed stage, they were transferred to an artificial spawning channel at Myers Point on Cayuga Lake.

A daily creel census was conducted on Cayuga Inlet each spring (1970-1974) from the opening day of the fishing season (April 1) until the number of fishermen on the stream was arbitrarily judged too few to justify continuation (mid-April). Due to the limited availability of field personnel, checkers were asked to examine as many fish as possible and record tag numbers. The minimum size limit for rainbow trout taken in this stream during the regular open season throughout the study period was 12 inches (30.5 centimeters).

All statistical tests were adapted from Steele and Torrie (1960) unless otherwise indicated.

RESULTS

A total of 10,415 rainbow trout were trapped at the fishway on Cayuga Inlet from October 1969 through April 1974. Of these, 444 were released untagged and 9,971 were released with tags. Of those released with tags, 583 had been tagged during previous migrations (recaptures) and 262 had been tagged earlier during the same migration (recycles).

Age Composition

Of the 10,153 scale samples taken from rainbow trout trapped at the fishway, 9,002 (89 per cent) were readable. The age distribution of these specimens is summarized in Table 1. Fall-run migrants spent an average of 1.8 $\pm$ 0.5 growing seasons in Cayuga Inlet and 2.0 $\pm$ 0.7 in Cayuga Lake. Spring-run migrants were slightly older, having spent an average of 1.7 $\pm$ 0.5 growing seasons in the Inlet and 2.5 $\pm$ 0.9 in the lake. The two oldest migrants exhibited two stream and six lake growing seasons on their scales.

Excluding recycles, 41 to 74 per cent (mean = 58 $\pm$ 12 SD) of the migrant fish were trapped during the fall run of each migration. Of the migrants tagged during the fall runs, 3.1 per cent were recaptured at the fishway during fall runs in subsequent migration periods, whereas 5.4 per cent were recaptured in the spring runs. For migrants tagged during spring runs, 1.3 per cent were recaptured during subsequent fall runs and 7.8 per cent were recaptured in subsequent spring runs. Over-all, 25 per cent of all

TABLE 1. AGE DISTRIBUTION, ACCORDING TO NUMBER OF GROWING SEASONS IN STREAM AND LAKE, FOR RAINBOW TROUT TRAPPED IN CAYUGA INLET DURING THE FALL AND SPRING MIGRATION PERIODS OF 1970 TO 1974

Habitat	Number of growing seasons					
	1	2	3	4	5	6
	Fall migration period*					
Stream						
Per cent	26.0	69.9	3.9	0.2	0.0	0.0
Standard deviation	6.1	5.2	2.0	0.4	. .	. .
Number of fish	1,358	3,649	204	10	0	0
Lake						
Per cent	20.8	60.8	14.4	3.7	0.3	0.0
Standard deviation	23.7	17.2	10.0	3.0	0.2	. .
Number of fish	1,086	3,174	752	193	16	0
	Spring migration period*					
Stream						
Per cent	35.4	61.1	3.4	0.1	0.0	0.0
Standard deviation	11.5	10.7	1.0	0.1	. .	. .
Number of fish	1,338	2,310	129	4	0	0
Lake						
Per cent	10.4	43.4	35.1	10.0	1.0	0.1
Standard deviation	11.1	5.9	7.4	4.1	0.7	0.2
Number of fish	393	1,641	1,327	378	38	4

*Each aged trout appears twice, once for the number of stream growing seasons and again for the number of lake growing seasons.

recaptures occurred during fall runs, and 75 per cent during spring runs. Of the 583 recaptures, 11 (1.9 per cent) skipped a migration period between tagging and recapture. These fish might have bypassed the fishway trap, spawned in another tributary of Cayuga Lake (strayed) or remained in the lake during the intermediate migration period.

SEX RATIO

The proportion of males among the rainbow trout trapped at the fishway ranged from 46 to 64 per cent (mean = 56 ± 8 SD) during the fall runs, while during the spring runs it was considerably less, ranging from 14 to 54 per cent (mean = 36 ± 14 SD). Within each run, males were more abundant than females in the younger age categories in both the fall and spring periods, whereas females predominated in the older age categories (Table 2).

The relationship of the recorded catch by angling to the number of tagged fish released is summarized in Table 3. The difference between the proportion of males among the tagged fish released at the fishway during the fall runs and that in the angler catch in Cayuga Inlet the following spring was significant ($P < 0.05$), but there was no significant difference during the spring runs. For the fall and spring runs combined, a chi-square test revealed that the proportion of males in the catch was significantly higher than that among the tagged males released during the

Tablf 2. Proportion of Males in Each Age Category, As Number of Growing Seasons, For Rainbow Trout Trapped in Cayuga Inlet During the Fall and Spring Migration Periods of 1970 to 1974

Migration period	Number of stream and lake growing seasons combined						
	2	3	4	5	6	7	8
Fall							
Percentage of males	72	60	57	39	30	0	0
Standard deviation	5	14	11	6	5	. .	. .
Number of fish*	73	959	2,881	795	135	2	0
Spring							
Percentage of males	79	58	37	22	15	0	0
Standard deviation	12	18	18	8	7	. .	. .
Number of fish*	112	602	1,625	989	181	9	2

*Total is less than that in Table 1 because about 7 per cent of the trout that were aged were not sexed.

Table 3. Proportion of Tagged Rainbow Trout Released in Cayuga Inlet During the Migration Periods of 1970 to 1974 That Were Taken By Angling in the Inlet During the Open Season Immediately Following the Period of Release

Migration period	Sex	Tagged fish released	Tagged fish caught	
			Number	Per cent
Fall	Male	2,831	196	6.9
	Female	2,421	122	5.0
	Total	5,252	318	6.1
Spring	Male	1,352	77	5.7
	Female	2,423	150	6.2
	Total	3,775	227	6.0
Total	Male	4,183	273	6.5
	Female	4,844	272	5.6
	Total	9,027	545	6.0

migration period immediately preceding the fishing season, indicating that male rainbow trout are more vulnerable than females to angling.

Length Composition

The average lengths of rainbow trout trapped during each migration period are given in Table 4 according to the number of growing seasons they had spent in the stream and in the lake. In general, fall migrants were smaller than spring migrants. The average difference in length between fall-run and spring-run fish was 2.6 centimeters for males and 3.0 centimeters for females. Paired t tests indicated that both sets of differences were significant ($P < 0.01$).

Fecundity

The relationship between pre-spawning body weight (body weight immediately prior to egg removal) and fecundity among the female rainbow trout held for artificial spawning was roughly linear. Analyses of

TABLE 4. AVERAGE LENGTH FOR EACH AGE CATEGORY OF RAINBOW TROUT TRAPPED IN CAYUGA INLET DURING THE FALL AND SPRING MIGRATION PERIODS OF 1970 TO 1974 ACCORDING TO THE NUMBER OF STREAM GROWING SEASONS AND LAKE GROWING SEASONS*

Stream growing seasons	Lake growing seasons									
	Male					Female§				
	1	2	3	4	5	1	2	3	4	5
Fall migration period										
1	31.7 (0.2)	34.9 (0.2)	43.8 (0.2)	49.3 (0.2)	57.6 (4.0)	31.1 (0.3)	36.1 (0.4)	44.6 (0.2)	50.5 (0.4)	63.5 (1.3)
2	33.7 (0.1)	38.3 (0.0)	47.5 (0.2)	52.9 (0.6)	. .	33.6 (0.1)	37.8 (0.1)	49.5 (0.1)	53.9 (0.3)	64.2 (3.7)
3	37.1 (1.0)	42.4 (0.2)	47.3 (5.4)	. .	. .	36.6 (0.2)	42.0 (0.2)	54.9 (0.9)	. .	. .
4	40.2 (0.0)	44.6 (0.4)	. .	. .	. .	. .	43.8 (0.0)	. .	. .	. .
Spring migration period										
1	29.1 (0.3)	37.4 (0.2)	46.7 (0.2)	52.7 (0.4)	59.3 (1.1)	35.1 (0.8)	41.8 (0.2)	48.2 (0.2)	53.8 (0.2)	61.6 (0.7)
2	34.2 (0.3)	39.9 (0.1)	52.6 (0.2)	56.3 (1.1)	. .	35.5 (0.1)	42.2 (0.1)	52.8 (0.1)	58.1 (0.3)	68.3 (1.4)
3	39.2 (1.7)	45.4 (0.2)	56.2 (0.9)	. .	. .	39.8 (0.8)	45.8 (0.5)	54.7 (2.8)	. .	. .
4	. .	46.4 (0.0)	. .	. .	. .	57.0 (4.7)	. .	. .	. .	. .

*Values in centimeters; figures in parentheses represent standard errors.

§In the spring migration period, there were values for females in their sixth lake growing season of 64.5 (±0.5) and 75.7 (±1.9) for one and two stream growing seasons, respectively.

covariance detected no significant differences ($P > 0.05$) in the fecundity per unit of body weight relationship among age classifications or migration periods, or between fall-run and spring-run fish. Therefore, fecundity data collected from all females held during the 5-year study were combined to derive a general relationship for the migrant population, i.e., fecundity = 376 + 1.9 X pre-spawning body weight in grams. Since both the pre-spawning body weight and fecundity were subject to measurement error, a Model II regression technique (Sokal and Rohlf, 1969) was used to estimate the regression coefficients. The correlation coefficient associated with the regression was significant ($r = +0.58$, $n = 270$, $P < 0.01$).

MORTALITY

Exploitation of tagged migrants in Cayuga Inlet was estimated by dividing the number of such fish released from the fishway during a migration into the number of tags returned by anglers who fished in the Inlet immediately following the migration. The resultant tag-return rates are

minimal estimates of exploitation because an unknown number of tags were probably not returned by anglers. The return rates for male and female migrants during the 1971-1974 migration periods are listed in Table 3. Chi-square tests revealed no significant differences ($P < 0.05$) in the average return rate between fall-run and spring-run migrants for either sex, indicating a high overwinter survival of fall migrants.

The apparently high overwinter survival for fall migrants is supported by the estimated annual survival rates of fall-run and spring-run migrants based on recaptures of migrants at the fishway during subsequent migration periods. A chi-square test revealed that the average recapture rate of fall migrants (8.5 per cent) was not significantly different ($P > 0.05$) than the average for spring migrants (9.1 per cent).

DISCUSSION

Differences in age composition, sex ratio and length composition between fall-run and spring-run rainbow trout in Cayuga Inlet support the general proposition that younger fish moved upstream earlier in the prespawning migration than older fish. Domination of the fall run by these younger individuals indicates that the period between runs during each migration was probably a period when environmental cues normally associated with upstream movement were absent.

The fall runs were dominated by males, which were generally younger than the female migrants. Similar observations of domination by males in the younger age categories were reported by Shapovalov and Taft (1954), Hartman (1959), Kwain (1971) and Hassinger et al. (1974). Hartman attributed his observation to a high in-stream exploitation of male trout, which was also the situation in this study.

The fall-run rainbow trout probably made an important contribution to the annual production of viable eggs in Cayuga Inlet. Their contribution, however, may be interpreted as positive or negative. In a positive sense, data presented in this paper indicate a high survival rate of fall-run migrants during the winter. Furthermore, 68 per cent of the males and 50 per cent of the females released with tags at the fishway during a migration period were released during the fall runs. Thus, the number of fall-run fish participating in spawning activity in Cayuga Inlet was probably high in relation to the number of spring-run fish.

In a negative sense, the number of potential spawners (fall and spring runs combined) may have exceeded the maximum number supportable in the Inlet. An overabundance of spawners may lead to redd superimposition if the spawning area is a limiting factor. Redd superimposition, a major source of density-dependent mortality in some salmonid populations (Neave, 1953), decreases the survival rate of the spawned eggs. In this case, removal of fall spawners by an in-stream fishery may have no effect on or

even increase the rainbow trout production in Cayuga Inlet. A regression analysis on a limited data base ($n = 3$) suggested that a negative relationship existed between the number of female rainbow trout released from the fishway and the abundance of young-of-the-year fish in the Inlet during the subsequent summer (Boreman, 1978). This implies that density-dependent mortality may have occurred.

LITERATURE CITED

BOREMAN, J. 1978. Life history and population dynamics of Cayuga Inlet rainbow trout (*Salmo gairdneri* Richardson). Ph.D. thesis, Cornell Univ. Library.

DODGE, D. P., AND H. R. MACCRIMMON. 1971. Environmental influences on extended spawning of rainbow trout (*Salmo gairdneri*). Trans. Am. Fish. Soc. 100:312-318.

HARTMAN, W. L. 1959. Biology and vital statistics of rainbow trout in the Finger Lake region, New York. N.Y. Fish and Game Jour. 6:121-178.

HASSINGER, R. L., J. G. HALE AND D. E. WOODS. 1974. Steelhead of the Minnesota north shore. Minn. Dept. Nat. Resources, Tech. Bull. 11.

KWAIN, W. H. 1971. Life history of rainbow trout (*Salmo gairdneri*) in Batchawana Bay, eastern Lake Superior. Jour. Fish. Res. Bd. Canada 28:771-775.

NARVER, D. W. 1969. Age and size of the steelhead trout in the Babine River, British Columbia. Jour. Fish. Res. Bd. Canada 26:2754-2760.

NEAVE, F. 1953. Principles affecting the size of pink and chum salmon populations in British Columbia. Jour. Fish. Res. Bd. Canada 9:450-491.

SEIFERT, M. F. 1968. Distribution and downstream movements of underyearling rainbow trout in Cayuga Inlet, New York. M.S. thesis, Cornell Univ. Library.

SHAPOVALOV L., AND A. C. TAFT. 1954. The life histories of the steelhead rainbow trout (*Salmo gairdneri*) and silver salmon (*Oncorhynchus kisutch*) with special reference to Wadell Creek, California and recommendations concerning their management. Calif. Dept. Fish and Game, Fish. Bull. 98.

SOKAL, R., AND F. ROHLF. 1969. Biometry. W. H. Foreman and Co., San Francisco, Calif.

STEELE, R. G., AND J. H. TORRIE. 1960. Principles and Procedures of Statistics. McGraw-Hill Book Co., New York, N.Y.

WITHLER, I. L. 1966. Variability in the life history characteristics of steelhead (*Salmo gairdneri*) along the Pacific Coast of North America. Jour. Fish. Res. Bd. Canada 23:365-393.

WATER-MASS MOVEMENT AND THE MIGRATION OF STRIPED BASS AROUND EASTERN LONG ISLAND, NEW YORK[1]

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ABSTRACT

A close relationship exists between the patterns of net water-mass flow and the seasonal migratory patterns of striped bass around eastern Long Island, New York. This suggests a relationship whereby striped bass may travel with the bottom water currents during their northerly spring migrations and with the surface water currents during their southerly fall migrations. The fish probably are not dependent on the currents for transport, but rather use them to their over-all advantage during migrations. Fluctuations in the character or properties of the currents could conceivably alter the spatial and temporal availability of the fish and thus the harvest. The properties of the currents might be affected by fluctuating local or regional meteorological conditions.

The striped bass (*Morone saxatilis*) is an important component of the inshore commercial and recreational fisheries of the northeastern United States (Koo, 1970; McHugh, 1972). As such, it has received much scientific attention over the last several decades, during which many studies have focused on the movement and migratory behavior of the species (Massmann, 1967; Pfuderer et al., 1975; Westin and Rogers, 1978). Although the over-all migratory patterns are well defined scientifically and are known (in a general sense) by most experienced fishermen, the fluctuating abundance and availability of striped bass spatially and temporally at a given location are less understood.

Striped bass are caught in the coastal waters of Long Island, New York, primarily in the spring and fall (Koo, 1970) during their migrations from and to their breeding and overwintering areas to the west and south. The New York commercial fishery is primarily one of haul seines, with lesser catches by otter trawl, gill net, pound net and hand line (Koo, 1970). Since 1970, 69 to 99 per cent of the reported harvest has been from Suffolk County on eastern Long Island, and most of this has been from the waters east of Riverhead, where most of the fishing is done. In recent years, the commercial harvest during the fall (October-November) has constituted 25 to 66 per cent (mean = 45 per cent) of the annual total, while the corresponding figures for spring (April-June) have been 14 to 38 per cent (mean = 26 per cent). The greater fall harvest occurs during the southerly

[1]Derived from a paper presented at the 1979 Northeast Fish and Wildlife Conference, Providence, Rhode Island. The author wishes to thank: Dr. Herbert M. Austin of the Virginia Institute of Marine Science, Richard H. Schaefer of the National Marine Fisheries Service, Dr. J. L. McHugh of the State University of New York at Stony Brook, Dr. Rudolph Hollman of the New York Ocean Science Laboratory, and Albert C. Jensen of Conservation Associates for reviewing the manuscript; Mary T. Hickey for review of the manuscript and preparation of the figure; and James W. Lester, Amagansett, N.Y. for information on the fluctuating harvest of striped bass and tag return data for Montauk, N.Y.

migration when the fish are readily available to the gear in the eastern bays and along ocean beaches. During the spring, fewer fish are taken in or near the shore zone, and catches are made farther offshore by boat anglers and trawlers.

Two recent studies performed independently and during the same time period produced similar results which, when coupled with harvest phenomena of the recreational and commercial fisheries, may help to explain some of the seasonal and spatial variations in striped bass availability on eastern Long Island. Hollman and Sandberg (1972), in studying the residual drift of surface and bottom waters of eastern Long Island in 1970, described a complex pattern of movement and exchange of water masses between Long Island Sound, Block Island Sound and the Atlantic Ocean. They discussed the results of their own drifter study and reviewed the literature of previous studies, with the following general conclusions.

1. There exists in central Long Island Sound a large counterclockwise gyre with a general movement of surface water away from the Connecticut shore.
2. The resultant movement of the surface gyre is a residual drift toward the southwest away from the Connecticut shore and a residual drift toward the northeast along the northeastern shore of Long Island and out of Long Island Sound into Block Island Sound.
3. The residual surface drift of central Block Island Sound is generally to the southeast. In southern Block Island Sound the surface drift is to the east out of the Sound, where it apparently becomes entrained in the longshore current moving westward along the southern shore of Long Island. The surface drift in northern Block Island Sound is to the north and east in the spring and summer, and to the west in the fall.
4. The residual drift of bottom waters through Block Island Sound is generally to the west into Long Island Sound and Gardiner's Bay, with sources of the bottom water from the New York Bight which enters through the passage between Montauk Point and Block Island. Bottom waters from the Cape Cod area enter Block Island Sound between Point Judith (Rhode Island) and Block Island.
5. In Long Island Sound the residual drift of bottom water is to the northwest toward Connecticut.
6. The residual eastward surface drift and the residual westward bottom drift of water masses in Long Island Sound create an upwelling of waters, the most prevalent of which is at the Connecticut shore between New Haven and Old Saybrook, while another but lesser upwelling occurs along the Long Island shore between Mattituck Inlet and Orient Point.

A further confirmation of this exchange and movement of water masses in the Atlantic Ocean, Block Island Sound, Long Island Sound and the Peconic Bay system was obtained during a series of synoptic oceanographic and biological sampling operations in 1972 and 1973 as reported by Austin and Stoops (1973), Nuzzi (1973) and Austin (1974).

Quite coincidentally, Austin and Custer (1974, 1977), in studying the seasonal migration of striped bass in Long Island Sound during the years 1969-1973, described a migratory pattern very similar to the water circulation pattern described by Hollman and Sandberg. In summary, Austin and Custer concluded:

1. The greatest spring influx of fish into Long Island Sound occurs at the eastern end around Orient Point through Plum Gut and The Race.
2. Most of the fish caught in Long Island Sound in the summer are captured by fishermen in the central Connecticut and central Long Island areas of the Sound.
3. There is a fall migration of fish from Massachusetts and Rhode Island into the eastern end of Long Island Sound.
4. Fish on the Connecticut shore appear to move from the eastern and western ends of Long Island Sound toward the central Connecticut shore before beginning a cross-over to Long Island in the fall.
5. Within Long Island Sound in the fall there is a heavy cross-Sound movement of fish from central Connecticut to central Long Island waters before emmigration out of the Sound, principally through the eastern passages.

The net flow of surface and bottom waters in Block Island and Long Island Sound was graphically depicted by Hollman and Sandberg (1972) and is presented here in Figure 1. The migratory pattern of striped bass described by Austin and Custer (1974, 1977) appears to fit this general pattern of water movement so that Figure 1 probably is equally representative of both phenomena. The resemblance between the two patterns suggests that striped bass might use or move with the water masses during their seasonal migrations into and out of Long Island and Connecticut waters, and perhaps in the areas north and east of Block Island Sound as well. It suggests that striped bass could travel with the bottom waters during their spring migrations and with the surface waters during their fall migrations.

This hypothesis of a relationship between striped bass migrations and water-mass movements may help to explain several fishery harvest phenomena. The commercial pound-net fishery in Fort Pond Bay at Montauk (Figure 1), according to Hickey and Lester (1980) and unpublished data collected by the same authors, captures striped bass primarily during spring and fall, with the fall harvest being considerably the greater. Good

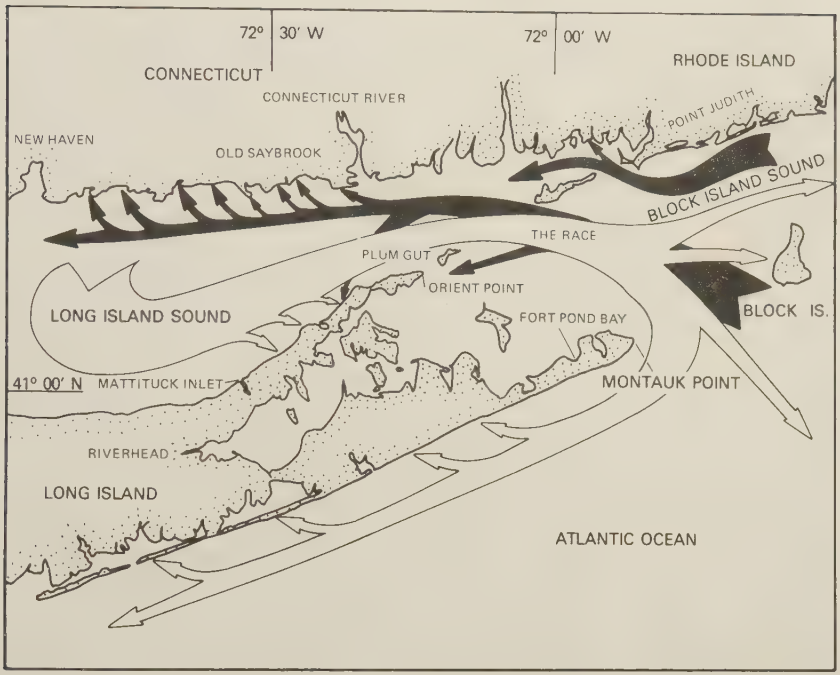

Figure 1. Graphic representation of the hypothesized migratory routes of striped bass around eastern Long Island, i.e., with the bottom water masses (black arrows) in the spring and with the surface water masses (white arrows) in the fall. Adapted with permission from Hollman and Sandberg (1972).

harvests during the fall occurred consistently after a period (1-3 days) of strong north or northeast winds. In years when the fall weather was mild or when the wind was seldom from a northerly direction, the harvest of striped bass was poor. On several occasions in the fall after prolonged northerly winds, striped bass were taken that had been tagged during the previous summer in cooperation with the American Littoral Society by fishermen in Connecticut waters at Stratford and Milford (James W. Lester, personal communication). The time-at-large for those fish ranged from 31 days (tagged in Connecticut during September and recaptured in Fort Pond Bay during October) to 113 days (July to November). If several striped bass travel with the surface waters during their fall migration, a prolonged northerly wind, which could conceivably alter the surface flow pattern to the south, could "bring" the fish into Fort Pond Bay as they approach Montauk Point on their way to ocean waters. Fish migrating in the surface waters in the fall would thus tend to be concentrated (or "entrained") in the inshore areas rendering them available to the pound-net gear (and also to seines in the surf zone). Conversely, during the spring, fish travelling with the bottom waters farther offshore would tend to be less available to shore-zone gear. This is further evidenced by the operations of

commercial trawlers which capture striped bass offshore during the spring and very close to shore in the fall. Some trawlers have been seen to fish so close to shore in the fall that their inshore otter door has broken the surface at the waterline on the beach.

The fall recreational fishery also produces greater quantities of fish than does the spring fishery, with very little harvest in the summer (Briggs, 1965). The over-all catch per unit of effort for striped bass by the surfcasting, private boat and charter boat fisheries at Montauk during 1973-1975 was greater during the fall than during either the spring or summer (Young, 1976). Fall anglers take striped bass from boats, docks and jetties, as well as by surfcasting. During the spring, fish are taken less frequently by all methods. Fish taken by boat anglers during the spring are more often caught offshore in deeper water (particularly around Montauk Point), whereas in the fall most are taken by the "surface" inshore fishery. On the northern side of Montauk Point in the fall, striped bass have occasionally been found so close to shore as to be swimming around the feet of surfcasters. Good surf fishing in that area is known to occur during and after periods of northerly winds. It would appear from the data of Austin and Custer (1974, 1977) that striped bass anglers in the Long Island Sound waters of central Connecticut during the summer may be more successful than anglers fishing in the waters of New York at that time. The central Connecticut area, then, may afford favorable summering grounds for striped bass, perhaps as a result of either the upwelling of cooler more saline waters or their mixture there with the surface runoff from several Connecticut rivers in that region. Food sources also may be abundant there during the summer.

These data suggest that a relationship may exist between the patterns of net flow of surface and bottom waters around eastern Long Island and the seasonal migrations and availability of striped bass. It is possible that the fish use the water movement to some degree for transport when the current is flowing in their desired direction of movement. This phenomenon was suggested for striped bass in the Chesapeake and Delaware Canal, where more often than not the fish moved in the same direction as the current flow (Koo and Wilson, 1972). In doing so, the fish swam or drifted with the current. Generally, if the current flow was opposite to the desired direction, the fish seemed to prefer remaining stationary rather than swimming actively against it. Striped bass in the San Joaquin River in California avoided areas with high turbulence and areas of abrupt changes in stream flow (Kerr, 1953). They invariably sensed and sought areas of lower and uniform velocities. Also, they appeared to move *en masse* during tidal flows from one locality to another, apparently riding the flow. When given a choice of current velocities to swim against in experimental studies, juvenile striped bass always chose the path representing the least current (Westin and Rogers, 1978). A strong demonstration of preference for low

current was observed for striped bass in the Delaware River estuary where they were relatively more abundant in low-current areas than in areas with little or no protection from currents (Bason, 1971). These data suggest that striped bass do take advantage of favorable conditions and conserve energy when faced with undesirable water currents. These phenomena might thus apply to striped bass during their seasonal migrations around eastern Long Island where the fish could swim (or sometimes drift) with favorable prevailing currents and then take the path of least resistance when faced with opposing currents such as might be encountered in The Race (Figure 1) where the tidal currents can be as strong as 5 knots (some 8 feet per second).

It is not suggested that striped bass travel only with the bottom currents during the spring and only with the surface currents during the fall, for variability in these patterns surely exists since some are caught in the shore zone during the spring. However, the major shore-zone harvest occurs during the fall, and it is probable that striped bass are not dependent on any current or water mass for travel but rather use them to their over-all advantage during migrations.

Ocean currents which meander have been shown to affect the level of harvest of fish species that travel with them. For example, Seckel (1972) demonstrated that skipjack tuna (*Katsuwonus pelamis*) of the northern Pacific Ocean drift with the ocean currents from eastern waters westward to where they may enter the Hawaiian fishery. He showed that the fluctuating availability of skipjack to that fishery was largely controlled by the fluctuating interplay of several ocean currents. The effects of varying ocean currents may even mask the effects of year-class abundance on the harvest. Further, Seckel stated that the probable drift path and concentrations of the tuna schools are predictable and that such predictions would increase the harvest efficiency of the skipjack fishery.

In contrast to the skipjack fishery, the annual harvest of striped bass in New York has been largely dependent upon year-class abundance, although both have fluctuated markedly in recent years (Koo, 1970; McHugh, 1972; Schaefer, 1972; Austin and Hickey, 1978). If, however, the striped bass in New York swim with the prevailing currents, fluctuations in the character or properties of the currents (e.g., spatial relationships, direction, velocity, physical or chemical properties, or associated forage organisms) conceivably could alter the availability of the fish and thus the harvest. The properties of the currents may be affected by fluctuating local or regional meteorological conditions, as in Fort Pond Bay.

If indeed, the phenomena of water-mass movement and the migration of striped bass are related in Long Island waters, similar phenomena may exist for striped bass in other areas of their range on the eastern or western coasts of the United States. This hypothesis may also help to explain some of the seasonally fluctuating food habits of striped bass on Long Island's south shore. For example, Schaefer (1970) noted: (1) a predominance of

invertebrates (especially amphipods) eaten in the spring when the fish might be near the bottom; and (2) an increased intake of fish, especially the bay anchovy, in the fall when striped bass and bay anchovies were predominantly in the surface waters. This is a subject for further research.

LITERATURE CITED

Austin, H. M. 1974. The use of satellites and volunteers in coastal oceanographic research. Underwater Naturalist 8(3):22-25.

Austin, H. M., and O. Custer. 1974. Seasonal migration of striped bass in eastern Long Island as compiled from American Littoral Society tag returns. In: Fish Tag Seminar: 25-35. New York Ocean Sci. Lab., Montauk, N.Y.

_____ 1977. Seasonal migration of striped bass in Long Island Sound. N.Y. Fish and Game Jour. 24(1):53-68.

Austin, H. M., and C. R. Hickey, Jr. 1978. Predicting abundance of striped bass, *Morone saxatilis*, in New York waters from modal lengths. Natl. Mar. Fish. Serv., Fish Bull. 76(2):467-473.

Austin, H. M., and P. M. Stoops. 1973. A synoptic study of the surface waters of Block Island Sound and surrounding waters. Part II, zooplankton. Tech. Rept. 24, New York Ocean Sci. Lab., Montauk, N.Y.

Bason, W. H. 1971. Ecology and early life history of striped bass, *Morone saxatilis*, in the Delaware River estuary. In: An Ecological Study of the Delaware River in the Vicinity of Artificial Island, Part IV. Delaware Prog. Rept. 3 for period January-December 1970. Ichthyological Associates, Ithaca, N.Y.

Briggs, P. T. 1965. The sport fishery in the surf on the south shore of Long Island from Jones Inlet to Shinnecock Inlet. N.Y. Fish and Game Jour. 12(1):31-47.

Hickey, C. R., Jr., and J. W. Lester. 1980. Marine fishes of southern origins in New York waters and their contribution to the fishery. N.Y. Fish and Game Jour. 27(1):99-102.

Hollman, R., and G. R. Sandberg. 1972. The residual drift in eastern Long Island Sound, a preliminary report. Tech. Rept. 15, New York Ocean Sci. Lab., Montauk, N.Y.

Kerr, J.E. 1953. Studies on fish preservation at the Contra Costa Stream Plant of the Pacific Gas and Electric Company. Fish Bull. 92, Calif. Dept. Fish and Game.

Koo, T. S. Y. 1970. The striped bass fishery in the Atlantic States. Chesapeake Sci. 11(2):73-93.

Koo, T. S. Y., and J. S. Wilson. 1972. Sonic tracking of striped bass in the Chesapeake and Delaware Canal. Trans. Am. Fish. Soc. 101(3):453-462.

Massmann, W. H. 1967. A bibliography of the striped bass. Sport. Fishing Inst., Washington, D.C.

McHugh, J. L. 1972. Marine fisheries of New York State. Natl. Mar. Fish. Serv., Fish Bull. 70(3):585-610.

Nuzzi, R. 1973. A synoptic study of the surface waters of Block Island Sound and surrounding waters, Part I. Tech. Rept. 19, New York Ocean Sci. Lab., Montauk, N.Y.

Pfuderer, H. A., S. S. Talmage, B. N. Collier, W. Van Winkle, Jr. and C. P. Goodyear. 1975. Striped bass-a selected, annotated bibliography. Environ. Sci. Div. Publ. 615, Oak Ridge Natl. Lab., Oak Ridge, Tenn.

Schaefer, R. H. 1970. Feeding habits of striped bass from the surf waters of Long Island. N.Y. Fish and Game Jour. 17(1):1-17.

_____ 1972. A short-range forecast function for predicting the relative abundance of striped bass in Long Island waters. N.Y. Fish and Game Jour. 19(2):178-181.

Seckel, G. R. 1972. Hawaiian-caught skipjack tuna and their physical environment. Natl. Mar. Fish. Serv., Fish. Bull. 72(3):763-787.

Westin, D. T., and B. A. Rogers. 1978. Synopsis of biological data on the striped bass, *Morone saxatilis* (Walbaum) 1792. Marine Tech. Rept. 67. Graduate School Oceanog., Univ. Rhode Island, Kingston.

Young, B. H. 1976. A study of striped bass in the marine district of New York. Project AFC-8 (completion report for period September 15, 1972 to March 31, 1976). N.Y.S. Dept. Environ. Cons., Stony Brook, N.Y.

GENERAL NOTES

MOVEMENT OF TOURNAMENT-CAUGHT AND RELEASED BASS

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National tournaments of the Bass Anglers Sportsman Society were staged on the St. Lawrence River at Alexandria Bay in the fall of 1977 and again in the spring of 1978. Contest fishermen fished up and down the river, both in Canadian and United States waters, some even in Lake Ontario. Bass taken were held in pump-circulated live wells in the fishermen's boats and then transported alive in mesh bags to a central location for contest weigh-in. After being weighed, the fish were immediately passed to a Department hatchery truck and placed in oxygenated water. Department biologists measured and took scales from all the bass and weighed part of the catch. The fish were then tagged with serially numbered monel metal jaw tags carrying a printed return address and released in the river. The same release site was used for all fish and in both years. This paper presents preliminary data of the movements of those subsequently recaptured and reported by sport fishermen.

In September 1977, a total of 865 largemouth and 89 smallmouth bass were tagged and released. In June 1978, the totals were 1,037 and 428, respectively. Most returns were from the general fishing public, although some tags were returned from other contests. Fishing pressure was moderate to heavy in the river from Lake Ontario downstream to Jacques Cartier State Park with the heaviest pressure in the vicinities of Cape Vincent (mile 3), Clayton (mile 19), Alexandria Bay (mile 30) and Jacques Cartier State Park (mile 51).

The tag returns and distances travelled as of December 1978 are summarized in Table 1. For largemouth bass movement from the release site was similar in both years. For the

TABLE 1. DEGREE OF TAG RETURN AND DISTANCE TRAVELLED FOR LARGEMOUTH AND SMALLMOUTH BASS TAGGED AND RELEASED IN THE ST. LAWRENCE RIVER*

Species and year tagged	Number tagged	Tags returned		Distance travelled (per cent)	
		Number	Per cent	Less than 1 mile	Less than 4 miles
Largemouth bass					
1977	865	54	6	44	69
1978	1,037	134	13	52	81
Smallmouth bass					
1977	89	7	8	§	§
1978	428	36	8	39	55

*Return data as of December 1978.
§Data too few for significance.

smallmouth bass tagged in 1977 there were too few returns for analysis, but for those released in 1978 the data indicated greater movement than for the largemouth bass. The distribution of the distances travelled for the two species is shown in Figure 1. The maximum distance for largemouth bass was 9 miles in 1977 and 12 miles in 1978. For smallmouth bass in 1978 it was more than 20 miles.

The distance travelled in relation to the elapsed time after release for the fish tagged in 1978 is shown in Figure 2. The distribution demonstrates no discernable pattern or trend for either species. This comparison was not made for fish tagged in 1977 because tag returns were spread out over a longer period of time. It is interesting, however, that substantial numbers were reported caught within one-half mile of the release point 50 days or longer after release.

With respect to smallmouth bass, movement of the tournament-caught fish, which were taken at widely scattered locations and then released at a single common site, can be compared with that of fish captured in trapnets at various locations in the St. Lawrence River and

Figure 1. Distribution of distances travelled by bass released in the St. Lawrence River: (upper three graphs) angler-caught fish released away from their home territories (i.e., displaced); and (lower graph) trapnetted fish released in their home territory (i.e., not displaced). Data for trapnetted fish from Dunning et al. (1978).

released essentially in their home territories as reported by Dunning et al. (1978). Considering the former group as "displaced" and the latter as "not displaced", the data are given in Table 2. Testing by chi-square showed that the two distributions were different ($\chi^2 = 35.43$ with one degree of freedom, 95 per cent level of confidence) and indicated that the displaced smallmouth bass tended to disperse more than the not-displaced fish.

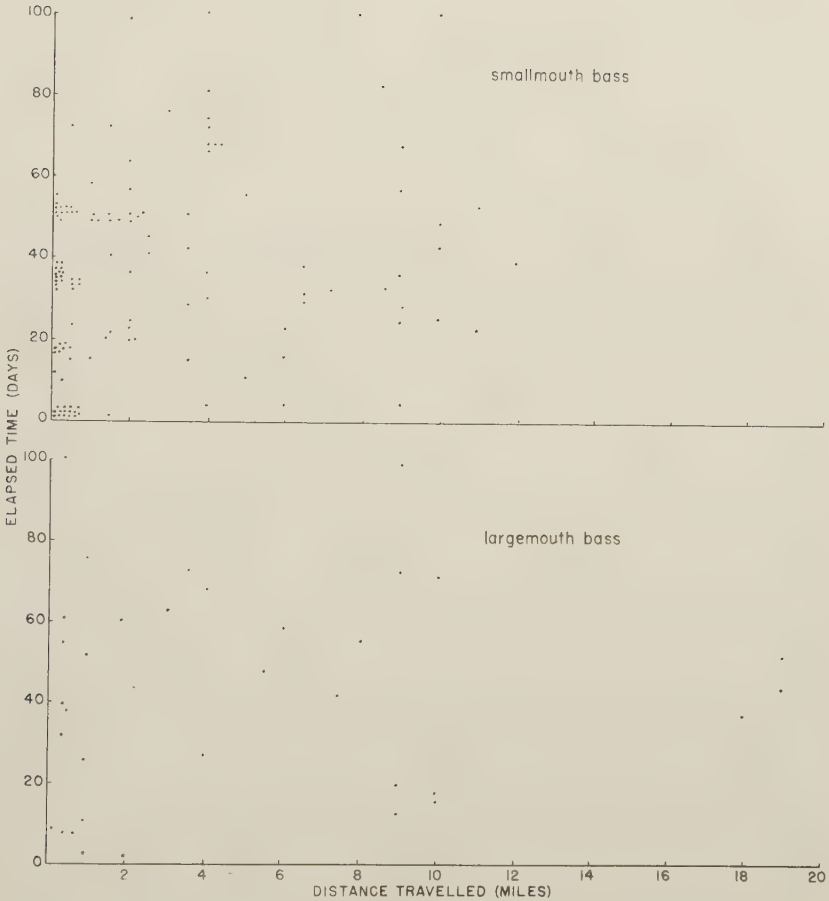

Figure 2. Distance travelled by angler-caught bass released at a common site in the St. Lawrence River in relation to the elapsed time after release.

Table 2. Comparative Movement of Smallmouth Bass From Release Site For "Displaced" and "Not Displaced" Fish

Group*	Distance travelled (miles)			
	Under 1	1 - 4	5 - 10	Over 10
Displaced	14	6	11	5
Not displaced§	23	4	2	2

*See text for definition of groups.
§Data from Dunning et al. (1978).

Literature Cited

Dunning, D. J., J. T. Evans and M. J. Tarby. 1978. Adult fish study, Technical Report D. In: Technical Reports, Environmental Assessment of the FY 1979 Winter Navigation Demonstration on the St. Lawrence River, Technical Reports, Vol. I. (Published by the N.Y.S. Dept. Environ. Cons. in conjunction with the State Univ. New York College of Environ. Sci. and Forestry)

OCCURRENCE OF JUVENILE BLUEBACK HERRING IN LAKE CHAMPLAIN[1]

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On September 21, 1979 two juvenile blueback herring (*Alosa aestivalis*) were collected with electrofishing gear along shore in water 1 to 2 meters deep in southern Lake Champlain near Chipman Landing, Vermont.[2] These specimens measured 87 and 94 millimeters in total length. A little over five weeks later, trap-netting operations on October 30 and 31 produced six additional young blueback herring in New York waters of Lake Champlain at Bouquet River Point, about 65 kilometers north of the collection site in Vermont.[3] The New York captures were made 30 to 90 meters offshore in water 1.2 meters deep over a sand substrate. Water temperature on October 30 was 11.1 ° C. Total lengths of these specimens were 91, 98, 99, 100, 104 and 108 millimeters, and age determinations indicated that they were young of the year.[4]

These observations are the first known records of either juveniles or adults of this anadromous marine species in Lake Champlain and its New York and Vermont watersheds. The Vermont collection also marks the first record of this species within Vermont. However, Loesch (1969) reported that adult blueback herring were passed over the Holyoke Dam in Massachusetts; thus they may have entered Vermont via the Connecticut River and not have been reported. The published range of the blueback herring in New York extends up the Hudson River into the lower Mohawk River including (based on the collection of adults) Crescent Lake and Niskayuna Lake near Schenectady (Greeley, 1935). However, more recent unpublished records in regional office files of the Department indicate its presence further upstream in both river systems than was reported in 1935. One record of particular importance in this instance was the collection of blueback herring in the Hudson River one-half mile south of Lock 2 between Waterford and Mechanicville (W. Elliot, Dept. Environ. Cons., personal communication). Further upstream, the Champlain Canal links waters of the Hudson with Lake Champlain and provides the most logical route for entrance of juvenile and/or adult herring into Lake Champlain.

The only alternate natural access into Lake Champlain for this species is provided by the Richelieu River, which discharges Lake Champlain waters into the St. Lawrence River. Collections of fish from the Richelieu River have failed to produce records of this species (V. Legendre, Quebec Ministere du Tourisme, Chasse et Peche, personal communication). Also, the only records of blueback herring from the St. Lawrence River or vicinity were four specimens collected in 1964 from Ellerslie, Prince Edward Island (Knott, 1978). Accordingly, it does not appear very likely that adults of this species penetrated Lake Champlain via a northerly route, and the most probable entrance remains the southerly route through the Champlain Canal from the Hudson River. However, whether the specimens reported here originated from the Hudson River, the Champlain Canal or spawning in the Lake Champlain drainage itself cannot be confirmed, and their significance may not be fully known until it can be determined if a freshwater population of blueback herring has established residence in Lake Champlain.

LITERATURE CITED

Greeley, J. R. 1935. Fishes of the watershed with annotated list. In: A Biological Survey of the Mohawk-Hudson Watershed: 63-101. N.Y.S. Cons. Dept.

Knott, E. 1978. A report of the blueback herring (*Alosa aestivalis*) from Prince Edward Island. Le Naturaliste Canadien 105:295-296.

Loesch, J. 1969. A study of the blueback herring *Alosa aestivalis* (Mitchell) in Connecticut waters. Ph.D. thesis, Univ. Conn. Library.

[1]Funded in part by New York Federal Aid in Fish and Wildlife Restoration Project FA-5-R.

[2]Identification of the Vermont specimens was confirmed by Rudolph Rosen of the University of Massachusetts.

[3]Identification of the New York specimens was confirmed by Dr. L. C. Smith of the American Museum of Natural History. Several have been put in the Museum collection and are catalogued AMNH No. 39137. Dr. Smith also assisted in obtaining current information on reports of blueback herring in New York and Canada.

[4]Age determinations for the New York specimens were made by Robert O'Gorman of the U.S. Fish and Wildlife Service at Oswego, N.Y.

OCCURRENCE OF THE BLANDING'S TURTLE IN NORTHERN NEW YORK[1]

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The Blanding's turtle (*Emydoidea blandingi*) is considered a threatened species in New York and information on its status and distribution is of interest. It was first reported in northern New York by Werner (1959), but, except for a brief mention of Wellesley Island and the (New York) mainland, no specific locality information was given. However, in personal correspondence (William E. Werner, Jr., January 12, 1978) Werner reported that he had collected one specimen approximately 3.2 kilometers south of DeWolf State Park on Wellesley Island and another from a woodland pond near the mainland entrance to the Thousand Islands bridge, south of Alexandria Bay. Both localities are in Jefferson County. Additional records from within this same general area were reported by Petokas and Alexander (1978). Since then two specimens have been recorded that extend the known range of this species in New York.

On June 13, 1979 an adult female Blanding's turtle (218 millimeters in plastron length) was found dead (road-killed) on Route 37 in the Town of Waddington in St. Lawrence County 0.5 kilometer southeast of Coles Creek. On September 17, 1979 an adult female (210 millimeters in plastron length) was observed walking on the Main Hawkins Point Road in the Town of Massena in St. Lawrence County 1.2 kilometers southeast of the Robert Moses State Park headquarters. These records extend the range of the Blanding's turtle about 105 kilometers northeast of its previous known range in Jefferson County. The evidence suggests that the range of this species in northern New York extends from the vicinity of Watertown northerly along the coastal plain of Lake Ontario and the St. Lawrence River lowland to the International Boundary near Massena.

No estimates of population density (e.g., number per hectare) have been reported for the Blanding's turtle, but some indication of its relative abundance in northern New York was obtained from turtle studies at Cranberry Creek Marsh in Jefferson County. During 1977, 203 painted turtles (*Chrysemys picta*) and 95 snapping turtles (*Chelydra serpentina*) were collected (Petokas, 1979), but only five Blanding's turtles were taken (Petokas, unpublished). While the population level at this marsh seems unusually low, the available literature suggests that the Blanding's turtle is (or was) much more common in other parts of its range, particularly Nova Scotia (Bleakney, 1963; Dobson, 1971), eastern Massachusetts (Graham and Doyle, 1977), southern Ontario (Logier, 1925, 1931; Adams and Clark, 1958), Michigan (Lagler, 1943; Gibbons, 1968), northern Ohio (Conant, 1938; Langlois, 1964; Richmond, 1970), northern Indiana (Schmidt and Necker, 1935; Grant, 1936; Minton, 1972), and northeastern Illinois (Weed, 1922; Schmidt and Necker, 1935; Smith, 1961). In northern New York, however, the species is at the far eastern limits of its primary contiguous range (McCoy, 1973), and population levels in this region may be lower than average and perhaps unstable.

The Blanding's turtle is fond of basking and has been observed to bask singly (Walker et al., 1953; Judd, 1965; Prellwitz, 1976), in groups (Bleakney, 1963; Dobson, 1971), or together with painted turtles (Milnes, 1946; Richmond, 1970; Dobson, 1971). Yet despite extensive and frequent field surveys in the northern New York area, the authors have observed only one basking Blanding's turtle. If the number observed basking is some indication of the abundance of a particular species, as suggested by Shealy (1976) in his study of the Alabama map turtle (*Graptemys pulchra*), then the paucity of basking Blanding's turtles supports the conclusion that this species is less abundant in northern New York than in many other parts of its range.

LITERATURE CITED

Adams, Morton S., and H. Fred Clark. 1958. A herpetofaunal survey of Long Point, Ontario, Canada. Herpetologica 14(1):8-10.

[1]The authors wish to acknowledge the assistance of George E. Menkens, Jr.

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Bleakney, J. Sherman. 1963. Notes on the distribution and life histories of turtles in Nova Scotia. Can. Field-Nat. 77(2):67-76.

Conant, Roger. 1938. The reptiles of Ohio. Am. Midl. Nat. 20(1):1-200.

Dobson, Ross B. 1971. A range extension and basking observation of the Blanding's turtle in Nova Scotia. Can. Field-Nat. 85(3):255-256.

Gibbons, J. Whitfield. 1968. Observations on the ecology and population dynamics of the Blanding's turtle, *Emydoidea blandingi*. Can. Jour. Zool. 46(2):288-290.

Graham, Terry E., and Timothy S. Doyle. 1977. Growth and population characteristics of Blanding's turtle, *Emydoidea blandingii*, in Massachusetts. Herpetologica 33(4):410-414.

Grant, Chapman. 1936. Herpetological notes from northern Indiana. Proc. Indiana Acad. Sci. 45:323-333.

Judd, William W. 1965. Studies of the Byron Bog in southwestern Ontario. XXII. Observations on toads, frogs, and turtles. Can. Field-Nat. 79(2):142-144.

Lagler, Karl F. 1943. Food habits and economic relations of the turtles of Michigan with special reference to fish management. Am. Midl. Nat. 29(2):257-312.

Langlois, Thomas H. 1964. Amphibians and reptiles of the Erie islands. Ohio Jour. Sci. 64(1):11-25.

Logier, E. B. Shelley. 1925. Notes on the herpetology of Point Pelee, Ontario. Can. Field-Nat. 39(5):91-95.

_____ 1931. A faunal investigation of Long Point and vicinity, Norfolk County, Ontario. IV. The amphibians and reptiles of Long Point. Trans. Royal Can. Inst. 18(1):229-236.

McCoy, Clarence J. 1973. *Emydoidea, E. blandingii*. Cat. Am. Amphib., Rept.-136:1-4.

Milnes, Herbert. 1946. Amphibians and reptiles of Oxford County, Ontario. Can. Field-Nat. 60(1):1-4.

Minton, Sherman A. 1972. Amphibians and reptiles of Indiana. Indiana Acad. Sci. Monog. 3:1-345.

Petokas, Peter J. 1979. The turtles of Cranberry Creek Marsh: population and morphological parameters. M.Sc. thesis, State Univ. New York, College Environ. Sci. and Forestry at Syracuse.

Petokas, Peter J., and Maurice M. Alexander. 1978. Geographic distribution: *Emydoidea blandingi*. Herpetol. Rev. 9(3):107.

Prellwitz, Dwain M. 1976. Effects of stream channelization on terrestrial wildlife and their habitats in the Buena Vista Marsh, Wisconsin. M.Sc. thesis, Univ. Wisconsin at Stevens Point.

Richmond, Gary. 1970. The marsh awakens. Internat. Turtle and Tortoise Soc. Jour. 4(1):28-29.

Schmidt, Karl P., and Walter L. Necker. 1935. Amphibians and reptiles of the Chicago region. Chicago Acad. Sci. Bull. 5(4):57-77.

Shealy, Robert M. 1976. The natural history of the Alabama map turtle, *Graptemys pulchra* Bauer, in Alabama. Florida State Mus. Bull., Biol. Sci. 21(2):47-111.

Smith, Philip W. 1961. The amphibians and reptiles of Illinois. Illinois Nat. Hist. Surv. Bull. 28(1):1-298.

Walker, Warren F., Jr., Donald M. Green and George T. Jones. 1953. Growth of algae on the turtle *Emys blandingi*. Copeia 1953(1):61.

Weed, Alfred C. 1922. Reptile notes. Copeia 1922(112):84-87.

Werner, William E., Jr. 1959. Amphibians and reptiles of the Thousand Islands region, New York. Copeia 1959(2):170-172.

PREDATION ON IMMATURE MIDGES BY RECENTLY EMERGED COHO SALMON

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Survival of larval or recently emerged fish depends in part on the availability of suitable prey, particularly during the early stage of exogenous feeding. Other characteristics of suitable prey include susceptibility to capture and body size in relation to the size of the gape of the young fish involved. Furthermore, the timing of spawning often appears to be synchronized with subsequent prey abundance (Nikolsky, 1963).

Coho salmon (*Oncorhynchus kisutch*) spawn from October to January throughout their native range in North America (Scott and Crossman, 1973). In the Great Lakes region, where coho have been recently introduced, spawning usually occurs from early September to November (Scott and Crossman, 1973; Johnson, 1978). Fry emergence occurs from early March to late July on the West Coast. In two British Columbia streams Mundie (1969) found that immature midges (Diptera: Chironomidae) comprised 48 and 36 per cent of the number of organisms eaten by recently emerged coho salmon. Elsewhere, Mason (1976) found that chironomid larvae and pupae represented 63 per cent of the diet of recently emerged coho. In the Great Lakes region, Wagner (1975) found that 88 per cent of the prey taken by age 0 coho in April were chironomids.

In the Salmon River system in New York, Johnson (1978) recorded the emergence of coho fry from mid-May to mid-June in 1977. During May the stomach contents of 20 such fry (32-60 millimeters in total length, mean = 47 millimeters) from Orwell Brook (a tributary) were examined. Chironomid larvae and pupae comprised 62 per cent numerically, and 16 per cent by dry weight, of the food eaten. Homopterans (10 per cent) and ephemeropteran naiads (7 per cent) were the other major taxa present. Aquatic invertebrates comprised 76 per cent and terrestrial invertebrates only 24 per cent of the diet of these fry.

Coho fry in this naturalized population appear to exhibit a pattern of initial feeding similar to that found in fry on the West Coast. The data suggest that the availability of immature midges (chironomids) may be a critical factor in their survival. The small size (1.5-6.5 millimeters, mean = 3.2 millimeters), coupled with the poor swimming ability of many chironomid species (Pennak, 1953), presumably make them susceptible to capture by recently emerged coho. Thus, the availability of these organisms may be an important consideration in assessing the potential of a stream for producing coho salmon.

LITERATURE CITED

JOHNSON, J. H. 1978. Natural reproduction and juvenile ecology of Pacific salmon and steelhead trout in tributaries of the Salmon River, New York. M.S. thesis, State Univ. New York, College Environ. Sci. and Forestry at Syracuse.

MASON, J. C. 1976. Some features of coho salmon, *Oncorhynchus kisutch*, fry emerging from simulated redds and concurrent changes in photobehavior. Fish. Bull. 74:167-175.

MUNDIE, J. H. 1969. Ecological implications of the diet of juvenile coho in streams. In: Symposium on Salmon and Trout in Streams: 135-152. H. R. MacMillian Lectures in Fisheries, Univ. British Columbia, Vancouver.

NIKOLSKY, G. V. 1963. The Ecology of Fishes. Academic Press, London.

PENNAK, R. W. 1953. Freshwater Invertebrates of the United States. Ronald Press, New York.

SCOTT, W. B., AND E. J. CROSSMAN. 1973. Freshwater fishes of Canada. Bull. 184, Fish. Res. Bd. Canada.

WAGNER, W. C. 1975. Food habits of coexisting juvenile coho salmon, brown trout and rainbow trout in the Platte River, 1967 and 1972. Mich. Dept. Nat. Resources, Fish. Res. Rept. 1831.

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